APRIL—20¢

POPULAR SCIENCE

SEE PAGE 62 IN THIS ISSUE

SHALL WE QUIT BUILDING BATTLESHIPS?

"Better than a rabbit's foot!"

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Here at Fisher, we want to make sure it's the *right* answer. That's why we give our tanks, bombers, and anti-aircraft guns the best we've got in us. We're using every craft we've mastered, every special skill we've developed—and they add up to an impressive number — to give our armed forces that all-important edge.

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To meet the promise, there were neither motors enough nor parts enough at the factory. From dealer stocks extra motors were recruited to fill the requirement. Assembly lines were swiftly organized to build up new motors from spare parts. Army officials gave unceasing cooperation to speed the job. Saturday night, loaded in express cars cut into a fast passenger train, the Commando's motors were on their way!

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OUTBOARD MOTORS

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POPULAR SCIENCE

FOUNDED 1872 MONTHLY VOL. 142 NO. 4

Mechanics & Handicraft

A TECHNICAL JOURNAL OF SCIENCE AND INDUSTRY

CONTENTS for APRIL, 1943

News

Men Behind Barbed Wire..... 49
Factory Roof Floats on Air..... 54
Your Cup of Coffee..... 58
Why Do We Build *Battleships?*..... 62
Our 155-mm. Howitzer..... 74
Canada Goes Industrial..... 78
War Drafts the Man in the Mask..... 82
How to Save Your Clothes..... 90
"Luxury" Life Raft for Air Crews..... 94
Why We Have the Best Flyers..... 96
The Battle of the Kilowatts..... 107
Morale in Boxes..... 114
Flying Sharpshooters..... 118

Automobiles

Wartime Maintenance of Cars..... 126
Four Useful Auto Hints..... 132
Gus Wilson's Model Garage..... 133

Home and Workshop

Making Every Exposure Count..... 136
Realistic Naval Bombing Game....HW 65
Colonial Sewing Cabinet.....HW 68
Getting Started in Beekeeping.....HW 74
Repairing Inside Door Locks.....HW 80
Using the Milling Machine.....HW 88
How to Build Temporary Staging..HW 98
Experiments with Aluminum.....HW 105
Rebuilding a Vacuum Cleaner.....HW 110
First Steps in Electronics—II.....HW 114

Departments

Cover: Painting by Jack Coggins
Our Readers Say..... 6

HARD-HITTING HOWITZER. Japs in the Pacific and Germans in North Africa have felt the wicked punch of the Army's 155-millimeter howitzer. It gets over the ground at 50 miles an hour; a battery can halt, place its guns, and start lobbing 100-pound shells at the enemy in less than eight minutes. Read about this great gun and the men who handle it in an article on page 74.

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HOME & WORKSHOP EDITOR Arthur Wakeling
ART EDITOR . . . . . Carsten Grande

EDITORIAL ASSOCIATES: Fred O. Newman, Alden P. Armagnac, B. T. Richards, Harry Samuels, Michele de Santis, Harry Walton, Don Romero, Bernard Wolfe, Jack O'Brine, Mary O'Connor, J. Harold Hawkins.

ART ASSOCIATES: Stewart Rouse, Wayn Smith, William Patrick.

PHOTOGRAPHY: William W. Morris, Robert F. Smith.

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Coming Next Month

PETROLEUM is the basis of the chemistry of this war, as coal was of the last. "Black gold" now gives us not only aviation and automotive fuel but also explosives, rubber, and a host of other things we must have to win. An article describes the chemical magic that makes oil America's ace in the hole.

YOU'VE BEEN HEARING a lot about the B-24 Liberator bomber, and you'll hear more as growing armadas of these heavy, fast carriers of destruction smash away at our enemies on every front. We give you an intimate portrait of "Miss Liberator"—her interesting past, her promising present, and her certain future in helping free the world from tyranny.

JUNIOR COMMANDO COURSES constructed at high schools in various parts of the country are giving boys the same kind of "toughening-up" training that fits Rangers and Commandos for their strenuous activities. Photographs and drawings show how to lay out such a course and build obstacles suited to the physical powers of boys of high-school age.

UNSUNG HEROES of the war at sea are the men of the U. S. Navy's Armed Guard, gun crews that do their fighting from the rusty decks of cargo ships as the convoys plow their way through aerial bombardment and submarine torpedo attacks. Here's the story of the boys who are getting the food and weapons to our fighting men on far-flung fronts.

"ARTIFICIAL FEVER" has gone to work in the factory! In a brand-new technique called "Radiothermics," electric waves carry even heating deep into materials to perform a multitude of jobs faster and better than was ever possible before. Read about this amazing development and the strange tasks to which it is being applied.

MICROFILM COPYING is becoming increasingly important in the preservation of business records and in special uses such as the transmission of letters to service men by V-Mail. Amateur photographers who would like to try their hand at this technique will find directions for building simple equipment that will enable them to make sharp, clear microfilm negatives with a miniature camera.

Leave it to the women to see that the airplane fits right into our everyday life. And it won't be long before they'll get their chance. When victory is finally won, the Air Age of family planes, super luxury liners, and giant commercial cargo ships will be born in America.

That's why we address these suggestions about airplane comfort and safety to the women.

First, when your husband goes out to buy tires for the family plane, exert your all-important family influence in favor of smoother, safer-landing B. F. Goodrich Silvertowns. (If your boy is in the Air Corps today, he may well be flying on these tires right now.)

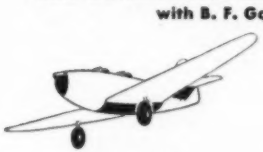
Of course, you'll want brakes that stop your plane safely and smoothly with only a slight pressure of your toe. So--remind him that B. F. Goodrich Expander Tube Brakes do just that (even on a 30-ton Flying Fortress).

As for the De-Icers on your family sedan-of-the-air, rest assured they'll be made by B. F. Goodrich. (They're the ones our air forces are now using.)

Our aeronautical division makes more than 80 different rubber products. All of them are helping America's air armada hasten the day of victory, bringing the Air Age that much closer.

So, when the time does come for you to fly, Mrs. America, remember you can't do better (or fly more safely) than by equipping your plane with B. F. Goodrich aviation products.

Here are some famous military trainers that are supplied with B. F. Goodrich equipment



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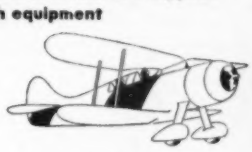

WACO

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FIRST IN RUBBER

Readers Say:

Their Heads Are Sooty But Unbowed

FOLLOWING the suggestion that you printed in "Readers Say" for February of throwing old flashlight batteries in the coal furnace to clean out the flue, I decided to try the same trick in my fireplace. Result: clean as a whistle—although the explosion cleaned the fireplace out of wood, fire, and ashes, and left us with the critical problem of cleaning up the room before the flying embers and logs had burned up the floor. My wife and I were sitting in front of the fireplace when the explosion occurred. We were both knocked over backward, and when we picked ourselves up we found we were covered with soot. We still think, however, that this clean-out idea is a good one.—J. S. D., New Iberia, La.

Visibility Was Better South of the Border

I AM writing to you in connection with the problem submitted by J. L. of New York, N. Y., in your January issue. The problem is: a man has $100 with which he has to buy 100 dresses—no more or no less. In these 100 dresses he has to include 50-cent dresses, three-dollar dresses, and 10-dollar dresses—and he must spend exactly $100. How many dresses of each kind does he have to buy? We consider ourselves wizards of "math" but we are still in a fog as to the solution. J. L. says he got the answer in about three minutes. I have worked at it steadily for three hours, and I still haven't got the answer—which I would very much appreciate receiving.—A. T., South Altoona, Pa.

I AM writing to submit the answer to J. L.'s problem that appeared in the January issue: 94 50-cent dresses, one three-dollar dress, and five ten-dollar dresses. Total expenditure: $100; total number of dresses: 100.—H. M., Monterrey, Mexico.

Things Are Booming Down in Australia

I WOULD like to pass along to you an item reprinted from an Australian newspaper which I think might be of interest to your readers. Mrs. John McCarthy, of Radwick, Australia, says she feels as if she has spent most of her married life living on top of Mt. Vesuvius. Her husband,. an amateur inventor in search of a rubber substitute, has, in the course of his experiments during the past year, exploded Mrs. McCarthy and her seven children out of the house on three different occasions; has set fire to the house, has ruined 17 of her aluminum saucepans; has wrecked the gas stove; and ruined the Christmas pudding. Mr. McCarthy also spent a lot of time trying to make two pounds of butter appear where only one formerly existed. He produced the two pounds of butter all right, says Mrs. McCarthy, but no one could eat the stuff except Mr. McCarthy who stoutly insisted that it was delicious. "Sundays are the worst," says this patient wife. "Nothing but explosions all day long."—A. M., Matheson, Ont., Canada.

Why Do Ships Carry Cargoes of Loading Machinery?

WHILE crossing the big "pond" I spent some time contemplating our ship and its numerous gadgets. I was especially impressed with the bulk, weight, and space occupied by the booms, winches, and other gear that make up a vessel's loading machinery. Then like a bolt from the blue I was struck by the apparent silliness of toting all that weight across the Atlantic when actually it is needed only at the ship's docks. I am therefore putting this question to the arm-chair experts of P.S.M's family of readers. Cargo-handling machinery is used only at the terminals of a boat's voyage, so why in the name of common sense is it being hauled all over the wet face of the globe?—A. V., Private, First Class, U. S. A.

We hope you don't mind, Private A. V., if our artist—a member in very good standing in our family of arm-chair experts—takes first crack at answering your question.—Ed.

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A big, new 24-page book of Paul Webb's "Mountain Boys" cartoons mailed by us to men in service. Send name and address with dime or War Savings Stamp which we will turn over to the U. S. O. in full.

HOW TO TAKE CARE OF YOUR GUNS AND AMMUNITION

Since factory stocks of sporting guns and ammunition are exhausted, "make it last" is a more important habit today than ever before. So we're offering some advice you may find helpful.

GUNS . . . if you're using Remington ammunition with Kleanbore* non-corrosive priming, just wipe the gun off with an oily rag occasionally to prevent rust, and put a drop or two of oil in the action.

Of course, if the gun has been out in damp salt air, or if it's gotten soaked, the barrel and action

should be thoroughly cleaned, then lightly oiled.

When you store a gun for any length of time, put it in a dry place away from excessive heat. It's a good idea to inspect it from time to time for signs of rust.

And remember, if you have any questions about care of guns, or repairs, call on your local gun dealer. He'll either know the answers or know where to find them.

AMMUNITION . . . the one important thing to do is to store ammunition in a cool, dry place.

And that's a good thing to remember these days!

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Readers Say:

Better Hurry, Mister. Life Can Be Awfully Short

I AM 14 years old, and interested in quite a few subjects. I happened to notice in your May issue an idea on perpetual motion. I have had the same idea in mind for several years now, and if it were not for financial difficulties, I would have had it published and patented by this time. I sincerely think that it would work. I enjoy P. S. M. very much.—A. K., Brooklyn, N. Y.

Looks Like We've Made a Flying Tiger Bristle

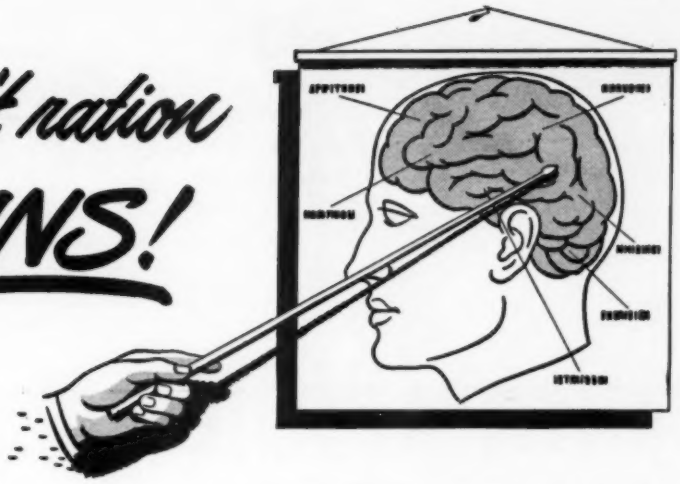
IN YOUR article on paint brushes in the February issue, you say that no new Chinese bristles are now being imported. I was one of the Flying Tigers in China, and was there until just recently. I know that a regular supply of these bristles does come from China.—C. J. R., Seattle, Wash.

We wouldn't think of contradicting a Flying Tiger, C. J. R., but may we say in self-defense that our information, which comes from an authoritative source, appears to be supported by (1) the development of a synthetic bristle (2) the Government's edict to brushmakers to mix horsehair with bristle in order to conserve the supply now on hand. We know that materials are being flown out of China, but is the amount of bristles being shipped anywhere near what was formerly imported into this country?—Ed.

Helium for Tanks Is the Latest Brainstorm Entry

I HAVE just read in the January issue the letter from A. H. W. of Phoenix, Ariz., concerning the piping down of Pikes Peak air for use in balloons. I believe I have a brainstorm that will top his. In all our planes we are trying hard to get greater lifting power. We know that helium, for instance, has what we are after. Why don't we, therefore, put helium into, say, our smaller tanks—compressing it so that it won't take up too much space, and yet putting in enough so that it will considerably lighten the tank. Wouldn't this be a big aid in the problem of carrying tanks by air?—B. J. L., Cleveland Heights, Ohio.

You can't ration BRAINS!



EVEN the brutalitarian dictators can't ration *brains!*

But, unfortunately, millions of individuals never make *all-out* use of the brains that God gives them. They go through life on one or two mental cylinders. Because the smartest man in the world can't operate a lathe, or read a blueprint, or design a new dive-bomber unless he has acquired TRAINING in a particular line of work.

How about *your* mental machinery — is lack of practical, modern training the monkey-wrench in the gears? Then mail this coupon, and learn how a low-cost I.C.S. Course can make you a trained man in a few months — without interfering with your present job!

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Readers Say:

Can You Satisfy His Insatiable Curiosity?

I HAVE an insatiable curiosity. I have been pondering on two questions for some time, and I would like to know what some of your readers think about them. First: what causes telephone and telegraph wires to give off a musical sound at various times? Second: why can't the impulses from a television transmitter be used to modulate long radio waves as is done in broadcasting stations? Maybe if I knew more about television I would know why it isn't being done.—C. C., Luther, Okla.

Resistance from the Rationing Board Would Be More

I HAVE a problem that has been bothering me for some time, and I would like to present it to your readers to see if they can figure out the right answer. Here it is: If a car were to travel forward at the rate of 30 miles an hour against no head wind whatever, would the air resistance it encountered be exactly the same as if the car were standing perfectly still and a head wind was blowing on it at a velocity of 30 miles an hour? I'd be glad to hear what your readers think. —S. A. S., Mount Bullion, Cal.

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- Replacing damaged cone
- Recentering voice coil
- Remedies for open field coil

Output transformer construction, repair
Gang tuning condenser:
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- How capacity varies
- Restringing dial cord
- Straightening bent rotor plates

I.F. transformers — What they do, repair hints
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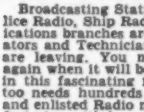

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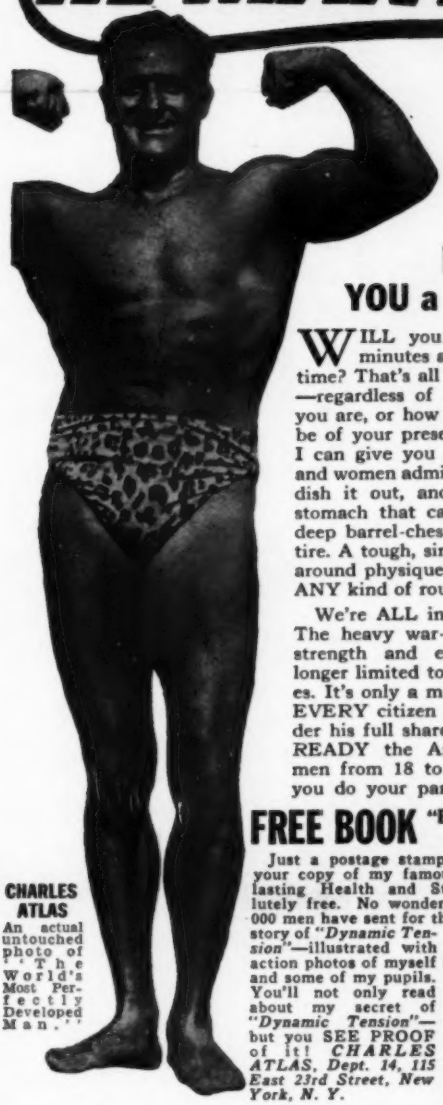

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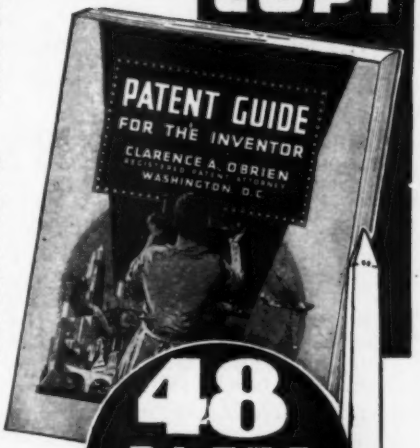

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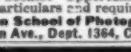

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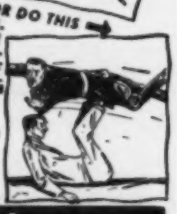

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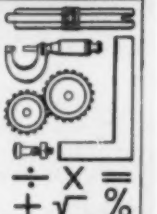

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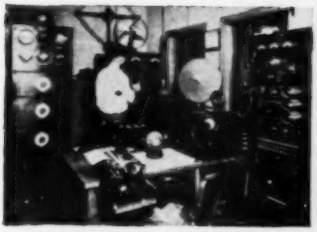

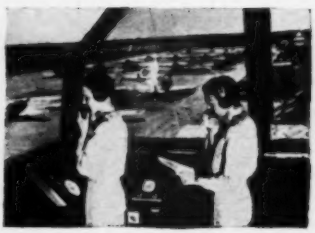

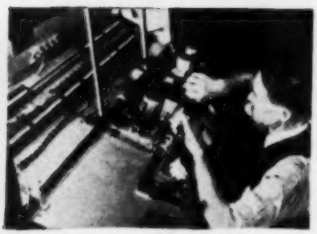

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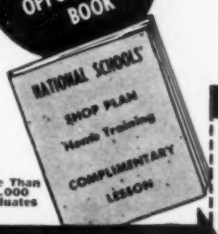

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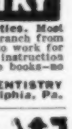

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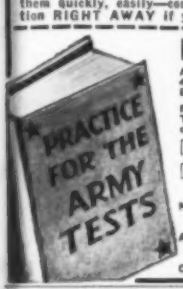

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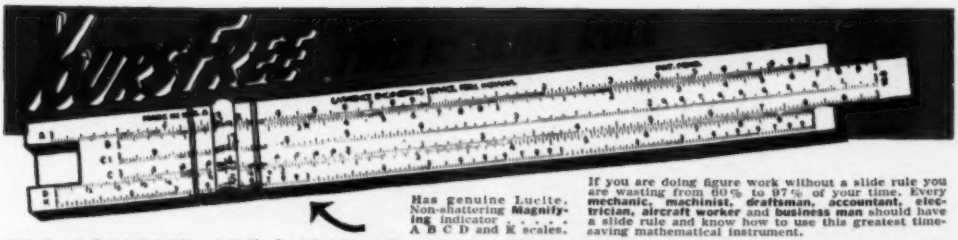

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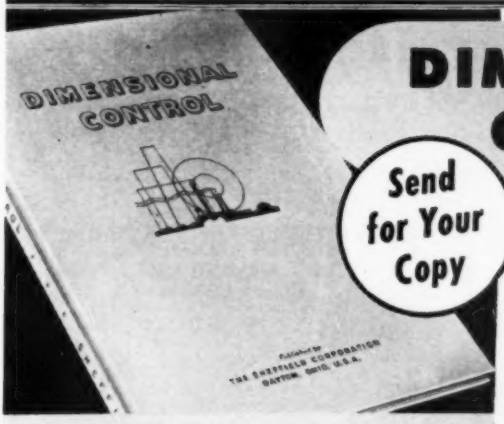

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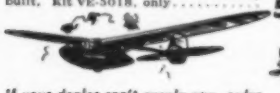

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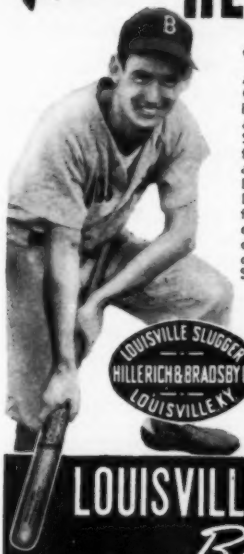

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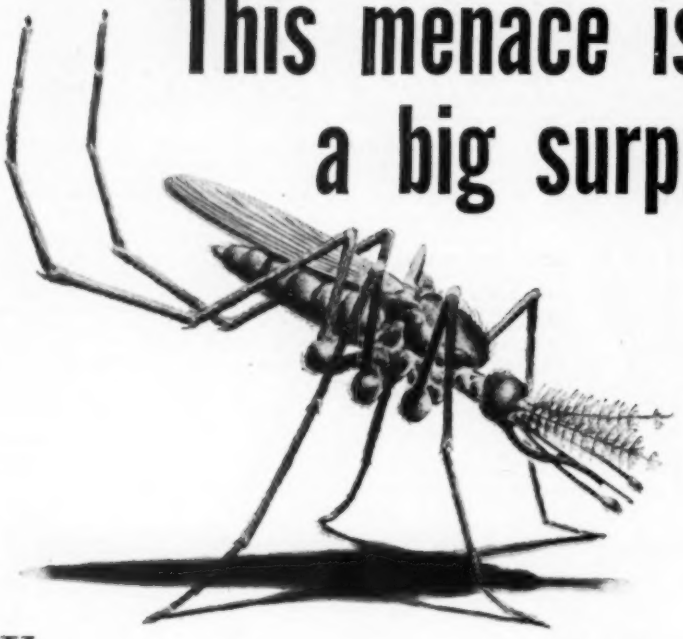

Her name is *Anopheles.*

She is the mosquito that carries malaria.

From now on, she'll be much less of a menace to our fighting forces in Africa and the Pacific, and to all of us here in America . . . thanks to a new Westinghouse development in the field of insect control.

Insect control! Funny thing for an electrical manufacturer to be concerned with?

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With this device, soldiers in combat zones can destroy every deadly insect in barracks, dugouts, captured enemy positions, in an amazingly short time—with complete safety to themselves. Cargo and transport planes returning to America from malaria-infested areas can be rid of disease-laden insects *in flight*, long before there is any danger of bringing these unwelcome stowaways into the United States.

Is this so important? A high military authority has said that *this new Westinghouse device may save more American lives than any other single invention of the war to date.*

And it is only one of many Westinghouse products that are helping to bring Victory nearer. In addition to all the electrical products we are making—and there are literally thousands of them—we are turning out such things as precision Army binoculars, huge steam turbines and reduction gears for ships of the Navy and Merchant Marine, plastic linings for Army helmets, control pulleys for aircraft, anti-tank shot, mountings for big Navy guns.

In peacetime, our principal business is *electricity.*

But in wartime, our only business is Victory. *And that means we are vitally concerned with* anything—*electrical or not—that our "know-how" can design or build to help win this war.*

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PLANTS IN 25 CITIES—OFFICES EVERYWHERE

Fighting boredom: Captured United Nations men loaf in the sun at a prison camp in eastern Germany, under the watchful eye of their Nazi guard. Monotony and the absence of privacy are the prisoner's worst foes

Men Behind Barbed Wire

WHAT IS BEING DONE FOR THE 6,000,000 FIGHTERS WHO ARE PRISONERS OF WAR? THIS ARTICLE GIVES THE ANSWER

By JACK O'BRINE

BEHIND strands of barbed wire that ring a thousand camps and compounds on five continents are the greatest number of war prisoners this earth has ever seen. Six million fighting men are there—counted out for the duration of World War II—and it's anybody's guess how many will follow them into captivity. Stripped of freedom and privacy, theirs could be a lost world. But amazing efforts are being made to prevent captivity from wholly wrecking their lives.

Not long ago, the problem of war prisoners seemed remote to us. But today, with our heroes of Wake Island, Guam, and Bataan interned, we are aware of the perils of barbed wire. Headlines that told of Nazi legions seizing half a million captives in the first month of the war have new significance. We recall announcements of British losses at Dunkirk, the capitulation of Dutch and Belgian armies, the staggering Russian, German, and Italian losses. We remember

German soldiers, left behind to cover the retreat of their unit, surrender to advancing Red Army men. Withdrawals are always productive of large numbers of war prisoners, as men are deliberately sacrificed to delay the enemy as long as possible, thus saving precious time for preparing new defensive positions

that flash reporting the surrender of 2,000,000 French soldiers. All of these men have been behind barbed wire for a long time now. They are under the watchful eye of their captors in 40 countries.

Americans can be proud of the work their organizations are doing to aid these sidetracked warriors of yesterday's battle lines. Through their international (and that is to say neutral) offices, the Red Cross and the Y.M.C.A. are the symbols of hope. They are the sole custodians of the benefits of the Geneva Convention of 1929—the agreement in which most of the civilized nations of the world pledged themselves to improve the lot of prisoners of war.

This is the first major test for the treaty. Remarkable is the fact that, with the war breaking virtually every other rule and pledge, the majority of the signatories have honored it. The Convention is a belated product of the first World War, when war-prison conditions hit a point f . below the recognized measure of refinement. But its authors hardly could have foreseen the problem in human welfare to be created 13 years later—the problem which the Y.M.C.A. and the Red Cross are striving so hard to solve.

Under the Convention, the Red Cross has five responsibilities. It is keeping a register at Geneva of all prisoners of war in all lands; it is forwarding and exchanging prisoners' mail; it is inspecting war prisoners' camps to check health and general living conditions; it is seeing that the convention is carried out, and, perhaps most important, it is distributing food, clothing, and medicines among the prisoners.

The Y.M.C.A. has the responsibility of preventing the dreary days and months of prison life from wrecking the lives of the prisoners. Through its program an astounding thing has happened. Practically all of the prison camps in Europe and Britain have their own universities. As many as 28 courses are taught in one prison camp, with subjects ranging from chemistry, medicine, and law to psychology, drama, and literature. The textbooks are supplied by the Y.M.C.A. representatives, who also provide equipment for craft shops, trades schools, and a multitude of other things, including sports and indoor games.

Most of the captor nations have permitted the organization of prisoners' committees, and it is through the leaders of these that neutral Y.M.C.A. representatives and the Red Cross deal. With the permission of the military authorities of the detaining power, they are making regular visits to the camps and talking freely with the camp leaders. Of constant concern is the question whether the prisoners are enjoying the fundamental rights established for them in the Geneva Convention.

These rights never existed before. Foremost is that capture of prisoners be made known to their own government immediately, together with official addresses to which their families may send mail; they are entitled to humane treatment and protection from violence and reprisals; they are to be fed and clothed by the detaining power; they are to be evacuated at once from zones of hostilities and, if wounded, given medical care and repatriation; officers among the prisoners are to be paid by the detaining power at the rate of pay of officers of the detaining power; enlisted men are to be paid for any work they do for their captors.

The majority of American prisoners of war are in the hands of the Japanese, whose

ITALIAN soldiers have been rounded up in masses like this in the Egyptian and Libyan campaigns. These were taken by the British when Tobruk fell

government, though signing the Geneva Convention, never has ratified it. According to a report from the British War Office, 5,000 Americans have been interned by the Japs, half of them in Formosa and the other half in Korea. There naturally has been anxious speculation as to the treatment of our men held by the Japanese, despite Japan's announcement soon after the start of the war that she would abide by the provisions of the treaty. Red Cross delegates permitted to inspect some of the camps and to speak to the prisoners have reported that conditions, on the whole, are satisfactory. They have received no serious complaints.

There are two main causes for worry with respect to our prisoners in Japanese camps. One of them is that months after their internment, Japan has failed to furnish a complete list of the prisoners. These men are posted as "missing in action" at Washington, and their welfare is causing increasing anxiety. But in December Japan announced that a list of the prisoners was being prepared for delivery to the Red Cross at Geneva, and blamed the difficulty of moving the prisoners for the delay. The other worry is over the food and clothing situation among the prisoners. They are being fed the ration of Japanese depot troops—largely fish and rice. It is feared that unless that diet is supplemented, the Americans may suffer from scurvy, beriberi, or other maladies. The Red Cross has succeeded in getting one shipment of supplies to Japan on a diplomatic exchange ship, and is ready to send great quantities of

GERMAN naval personnel, captured in a Commando raid on the Lofoten Islands, are marched blindfolded aboard ship. Below, a Nazi captive shows how the Australians mark their prisoners—with a pair of shorts bearing a red patch upon the seat

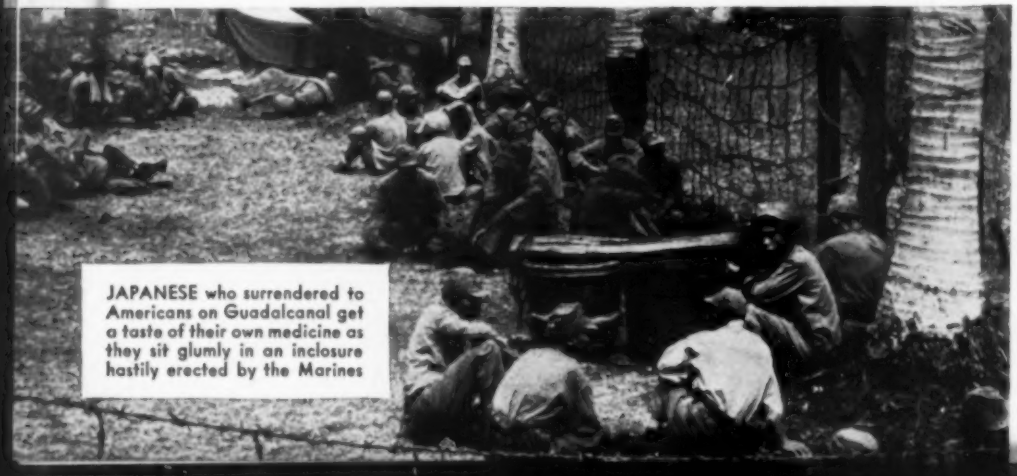
AMERICAN and British soldiers captured by the Germans in Tunisia wait under guard to be taken to the rear. The Yanks are easily identified by their pot helmets. Photograph came from Germany

specially prepared food parcels as soon as transportation can be arranged.

Outstanding among Red Cross accomplishments has been the preparation and distribution of these food parcels. They are the product of the nutrition staff of the American Red Cross in collaboration with United States Government agencies and the Army. They are appropriately called by those who know their contents "Eleven pounds of health." Contents of the parcel vary from time to time, but the normal content is: milk powder, 1 lb.; cheese, 8 oz.; liver paste, 6 oz.; corned beef, 12 oz.; potted pork, 12 oz.; raisins, 1 lb.; sugar, 8 oz.; lemon powder, 12 oz.; cocoa, 8 oz.; coffee, 8 oz.; chocolate, 4 oz.; candy, 6 oz.; cigarettes, 40; tobacco, 2¼ oz.; lunch biscuit, 7 oz.; matches, 2 boxes.

If the men in the prison camps can receive one parcel a week, which is the aim of the Red Cross, there would be no nutritional deficiencies. The food in the packages has been scientifically prepared to withstand temperatures up to 120 degrees without decomposing.

Reciprocity is the clew to success in meeting the problems in the treatment of prisoners in Europe and Britain. For the most part, the nations have adhered closely to the Geneva Convention in the treatment of each other's prisoners. Nazi treatment of Russians, Poles, and Serbs is another story. There have been reports of many



JAPANESE who surrendered to Americans on Guadalcanal get a taste of their own medicine as they sit glumly in an inclosure hastily erected by the Marines

"Eleven pounds of health": The Red Cross hopes to get food parcels like this to prisoners at the rate of one each week

Three Belgian officers, confined by the Germans since 1940, smile gratefully as they get the welcome Red Cross packages

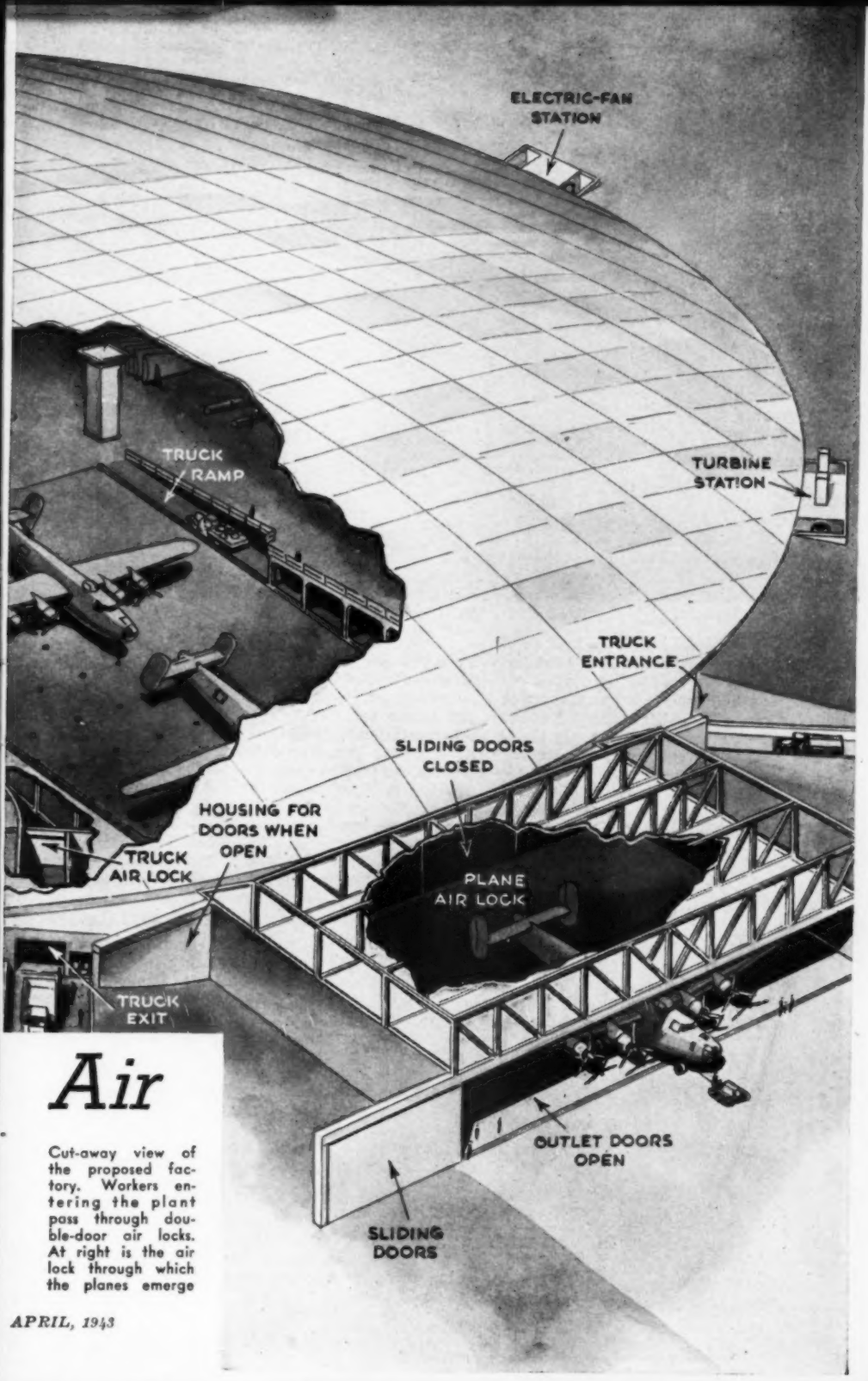
serious abuses in their treatment.

Russia's situation with respect to war prisoners is unique among the belligerents. The Soviet Union was not a party to the Geneva treaty, and neutral inspectors have been barred from Red prison camps. Charges and countercharges have been tossed back and forth between Moscow and Berlin from the time the first prisoners were taken. The Soviet has accused the Nazis of starving Red prisoners and subjecting them to systematic atrocities and outrages. The Germans have countered with claims that the Russians massacred their prisoners. But, if reports of newspaper correspondents may be used to judge the situation, Russian prison camps differ little from those of other nations.

Books help to pass the time for German soldiers who have been captured by the Russians and placed behind barbed wire

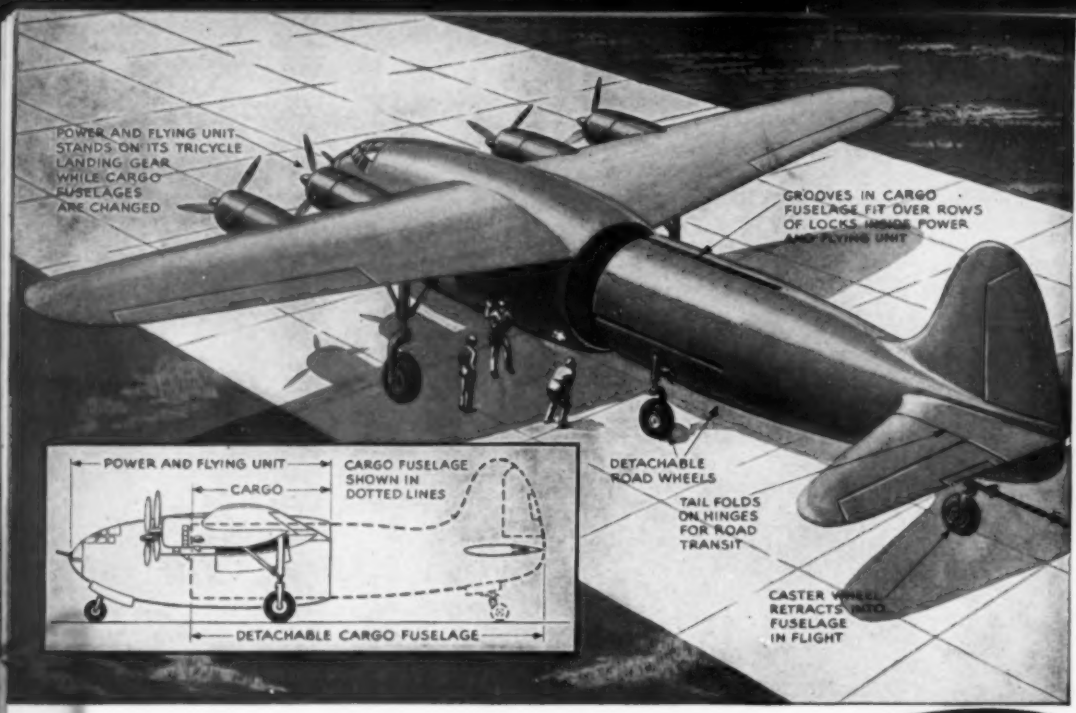
Factory Roof Floats on

TO ELIMINATE the columns and trusses that obstruct production in conventional plants, consulting engineer Herbert H. Stevens, Jr., of New York City, has designed an airplane factory in which the circular roof, 1,200 feet in diameter, is supported by an air pressure of only one ounce above normal atmospheric pressure (14.7 pounds per square inch at sea level). Sixteen fans and four exhaust towers provide ventilation in addition to the air pressure which, being low, will have little or no effect on the workers. Other advantages include quick construction, low operating cost, and the saving of vital materials. The roof will cover an unobstructed working area of 26 acres.



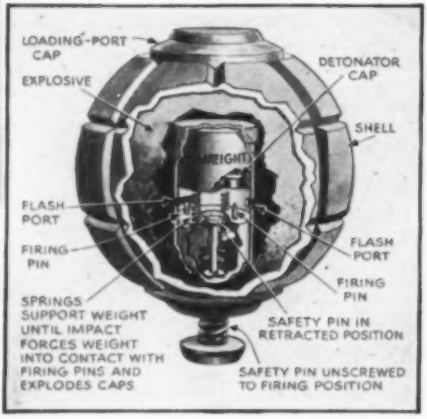
Air

Cut-away view of the proposed factory. Workers entering the plant pass through double-door air locks. At right is the air lock through which the planes emerge

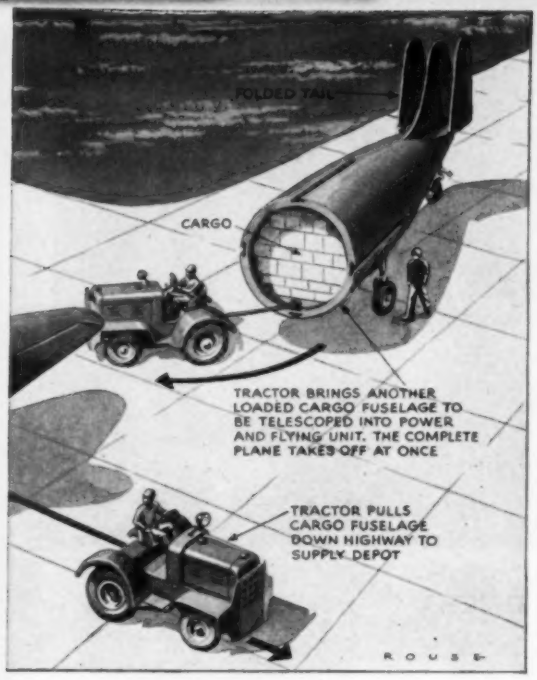

POWER AND FLYING UNIT STANDS ON ITS TRICYCLE LANDING GEAR WHILE CARGO FUSELAGES ARE CHANGED
GROOVES IN CARGO FUSELAGE FIT OVER ROWS OF LOCKS INSIDE POWER AND FLYING UNIT
POWER AND FLYING UNIT
CARGO
CARGO FUSELAGE SHOWN IN DOTTED LINES
DETACHABLE CARGO FUSELAGE
DETACHABLE ROAD WHEELS
TAIL FOLDS ON HINGES FOR ROAD TRANSIT
CASTER WHEEL RETRACTS INTO FUSELAGE IN FLIGHT

WAR

CARGO PLANES using the truck-trailer loading principle are envisioned by Benjamin C. Scheufele, of Philadelphia, Pa., as a means of speeding up air freight transport. Instead of having an urgently needed plane stand idle while its cargo is unloaded and outgoing freight is stowed, he provides a detachable fuselage section including the loading space and tail assembly. On arrival at a terminal airfield, this section is detached from the unit containing the wings, motors, and control cabin. Dragged away to the supply depot on removable road wheels and retractable caster tail wheel, it is replaced at once by a similar section already loaded with outgoing cargo, and the plane takes off after a minimum turn-around time. The cargo fuselage telescopes inside the forward section to insure rigidity, and to place the load in the necessary position under the wings. Tail planes fold upward for transit along roads to and from the loading depot. By keeping the motive part of the plane always busy, the inventor points out, this plan would get more service from available wings and power plants.



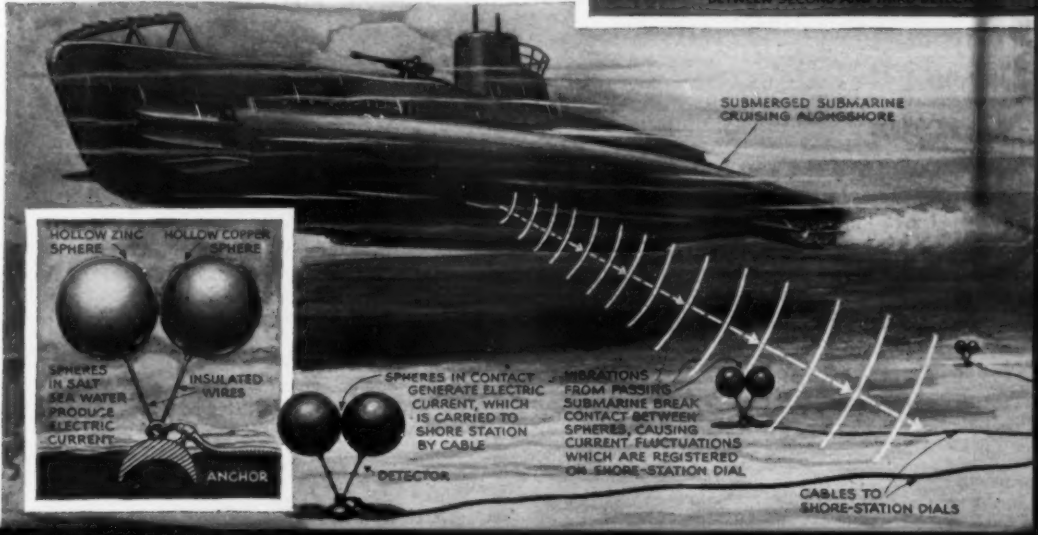
A HAND GRENADE that explodes on striking an object has been devised by George Keeling, of Ithaca, N. Y. Unlike earlier percussion grenades which utilized a projecting pin to detonate the explosive, the new missile employs a sliding weight containing the primer charge. A threaded safety pin holds this weight stationary until the grenade is armed for use. When the pin is unscrewed and the missile is thrown, springs hold the weight out of contact with the firing pins. Upon impact, inertia forces the weight against the firing pins, which set off detonator caps. Most grenades in use today are of the time-firing type, in which an internal fuse is ignited in throwing. These have the disadvantage that the fuse may give the enemy time to take cover or even to throw the grenade back.


FOLDED TAIL
CARGO
TRACTOR BRINGS ANOTHER LOADED CARGO FUSELAGE TO BE TELESCOPED INTO POWER AND FLYING UNIT. THE COMPLETE PLANE TAKES OFF AT ONCE
TRACTOR PULLS CARGO FUSELAGE DOWN HIGHWAY TO SUPPLY DEPOT
ROUSE

VISORS FOR ARMY HELMETS are given practical form by an invention of M. J. O. Lobelle, of Langley, England. The idea, which pertains chiefly to the method of hinging, provides a protective shield made of thin, perforated metal plate or a veil of chain mail. When not in use, the visor is swung up inside the steel shell of the helmet, as illustrated in the drawing above, and does not interfere with its normal comfort.

IDEAS

A SUBMARINE DETECTOR devised by the late Vladimir S. Goloviznin, of New York City, employs electro-chemical action to give warning of enemy undersea craft operating near the coast. Detector units, anchored in shallow water offshore, consist of pairs of hollow spheres of dissimilar materials which generate an electric current when in contact in salt water. The vibrations produced in the water by a passing submarine cause current fluctuations which are recorded on instruments ashore.


SUBMERGED SUBMARINE CRUISING ALONGSHORE
HOLLOW ZINC SPHERE
HOLLOW COPPER SPHERE
SPHERES IN SALT SEA WATER PRODUCE ELECTRIC CURRENT
INSULATED WIRES
ANCHOR
SPHERES IN CONTACT GENERATE ELECTRIC CURRENT, WHICH IS CARRIED TO SHORE STATION BY CABLE
VIBRATIONS FROM PASSING SUBMARINE BREAK CONTACT BETWEEN SPHERES, CAUSING CURRENT FLUCTUATIONS WHICH ARE REGISTERED ON SHORE-STATION DIAL
DETECTOR
CABLES TO SHORE-STATION DIALS

NORMAL YIELD
DIVIDEND
4 TABLESPOONFULS OF COFFEE GROUNDS WILL MAKE 4 CUPS
BUT ¼ TABLESPOONFUL OF CHICORY ADDED MAKES AN EXTRA CUP

WHAT YOU SHOULD KNOW ABOUT

Your Cup of Coffee

Substitutes Will Stretch Your Rationed Supply, and Simple Tests Will Detect Any Adulterants

WITH coffee now on the ration books, coffee lovers who previously turned up their noses at substitutes, additions, or "adulterations" are now investigating every possibility for stretching their allotments. Ground and roasted chick-peas, barley, beans, bran, wheat, rye, and chicory are being added to coffee to make it go farther. Cereal-and-molasses beverages are being used by some who desire the warmth rather than the stimulation of real coffee.

Catering to this demand for coffee "stretchers," coffee roasters and dealers have created blends of materials which may be added to coffee, making it go farther without appreciably changing its taste. In one instance, this material consists of roasted wheat and rye, with a little chicory added to give improved body and flavor. To allow the consumer to get his full ration of coffee, the "stretcher" is sold separately—a four-ounce package with each pound of coffee.

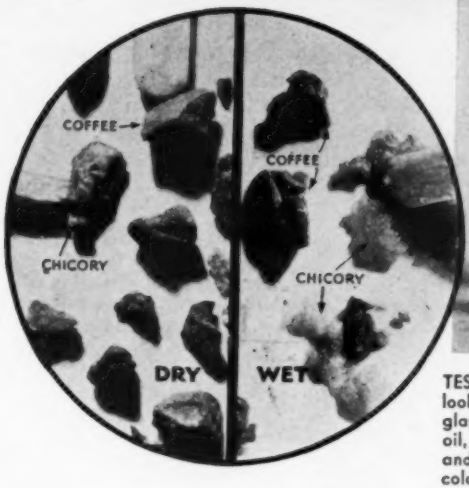
Chicory is one of the simplest, oldest, and most pleasant means of getting more cups from the coffee quota. Added discreetly, chicory not only stretches the potency of coffee and lowers its cost, but actually improves its flavor in the opinion of many connoisseurs. It is used almost universally in Europe and in Louisiana.

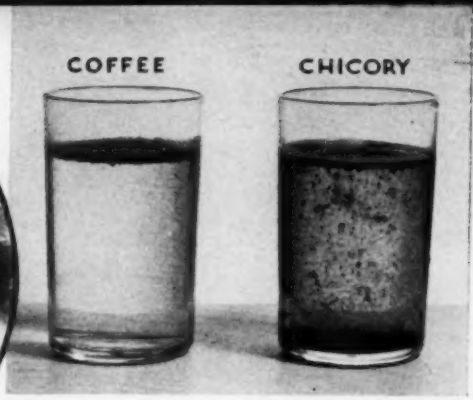
Only vaguely known to many Americans, chicory is a cultivated vegetable, resembling a carrot. At maturity, it is sliced, dried, roasted, and then either ground to match the coffee grounds of commerce or pulverized and pressed into little cakes.

Ground chicory should be mixed directly with the ground coffee, while the pulverized type may be added after the coffee has been made. The amount to use depends upon individual taste. In Europe and New Orleans, it may be as much as 25 percent, making a full-bodied coffee with strong flavor. A six-percent addition—or one ounce to each pound of coffee—might better suit the average American. Used in this proportion, it gives a bonus of an extra cup of coffee for every four, or ten extra cups for every pound.

Roasted cereals, peas, and beans may be used with coffee in proportions up to 25 percent. A little chicory with these improves the flavor.

Although none of these substitutes give you the "kick" of real coffee—lacking, as they do, caffeine and tannic acid—they are wholesome and harmless foods and add to taste satisfaction. On the opposite page are simple tests which will help you to test the purity of the coffee you buy.—KENNETH M. SWEZEY.

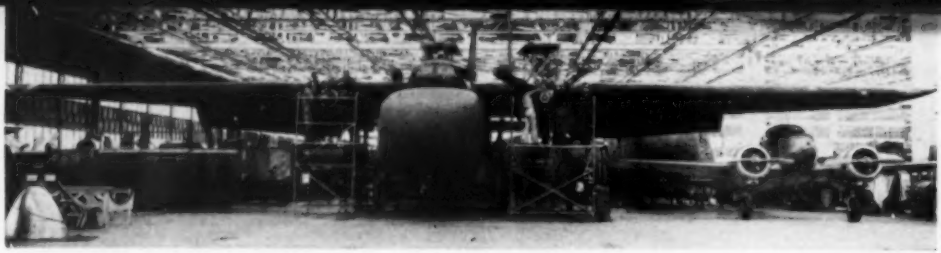


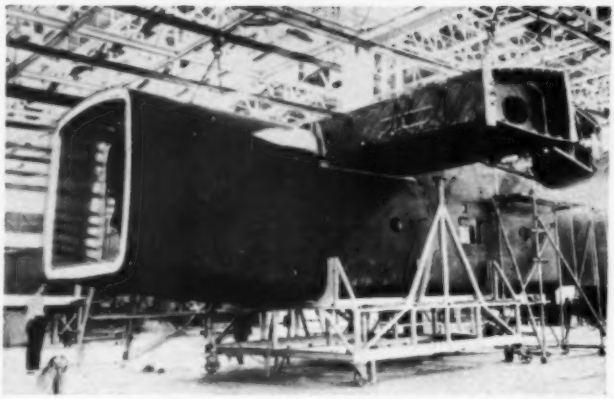


TESTING FOR CHICORY. Coffee grains are hard and look smooth-surfaced and granular under a magnifying glass; chicory, a root, is fibrous. Coffee contains oil, and floats on water; chicory becomes waterlogged, and sinks. Wet coffee grains stay hard and keep their color; chicory becomes gelatinous and turns very light

CEREAL SUBSTITUTES. Roasted barley (left) is both a substitute and a stretcher. Postum is a blend of roasted barley, roasted wheat, and molasses. Chick-peas, roasted and ground, are used as a substitute

TESTING FOR CEREALS. These substitutes and stretchers all contain starch, which can be detected by testing with iodine. Boil a few grains of the sample in water for a minute or two, let the liquid cool, and add several drops of iodine test solution or tincture of iodine. The color of pure coffee or a mixture of coffee and chicory will be affected very little, as the sample above left shows, but the starch in any cereal that has been added to the coffee blend will be turned blue-black, as at right



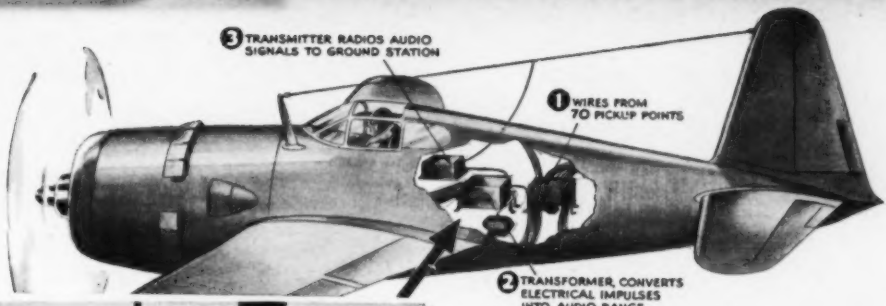


THIS GIANT CARGO PLANE, the new Curtiss C-76 Caravan designed to transport troops and supplies quickly to fighting zones, is basically an all-wood job that combines molded plywood (three to nine plies thick), laminated strips, and plain lumber. It has a wing span of 108 feet, is 68 feet long, and is powered by two 1,200-hp. motors. Woods used are hickory, spruce, birch, gum, mahogany, and fir.

Built like a box car, the fuselage of the C-76 will hold infantry, paratroopers, or military supplies. The crew's control section is over the cargo space

GRANDDADDY OF THE MODERN TANK, this armored car was a pioneer among self-propelled military land vehicles. It runs on steam generated in a boiler under the hood, and is armed with an 1895 Colt automatic Browning rifle. The inventor was Col. Royal P. Davidson, former head of Northwestern Military Academy, Highland Park, Ill.

TWO MACHINE GUNS of .50 caliber are coaxially mounted on an antiaircraft carriage in this version of the Army's defense against enemy planes. The mechanism includes automatic aiming controlled by a direction finder to allow accurate surprise firing on approaching planes, and also sights for manual operation. The new weapon is highly mobile, and its carriage can be lowered to the ground to take the force of the recoil off axles and wheels.


3 TRANSMITTER RADIOS AUDIO SIGNALS TO GROUND STATION
1 WIRES FROM 70 PICKUP POINTS
2 TRANSFORMER, CONVERTS ELECTRICAL IMPULSES INTO AUDIO RANGE

AERIAL UNIT of the new recorder, which will radio reports on 70 vital points in the plane during its test flight, is shown being installed by inventor M. Giffen, left

Test Flight Data Are Radioed from Plane

ENGINEERS of Vultee Aircraft, Inc., have developed a radio test-flight recorder that enables technicians sitting in a laboratory to get a complete picture of a plane's performance while the ship is being test-flown as far as 100 miles away. Readings on 70 of the plane's most important parts are automatically radioed from the plane to the laboratory where they are recorded simultaneously on wax disks and sound film. From these an electro-mechanical "brain" analyzes each reading as it is received and plots the trend of the analysis for visual study. Prime value of the device is the enormous amount of data it can handle and the speed and accuracy with which it can record it. Also should any danger arise in the plane, the pilot can be quickly warned, and if the plane crashes, valuable records are not lost as they used to be.

LABORATORY TECHNICIANS receive the flow of messages and record them on wax disks and sound film. In the event a dangerous weakness suddenly arises in the ship, the pilot is quickly warned

AUTOMATIC ANALYSIS of the sound-film recordings is made by this machine which reproduces them in the form of charts showing the individual behavior of every instrument that was under test

WHY DO WE KEEP ON BUILDING BATTLESHIPS?

WITH PLANES CHALLENGING THEIR SUPREMACY, THEY STILL HAVE WORK TO DO IN WAR AT SEA

By ALDEN P. ARMAGNAC

PEELING out of formation and whining down from the sky, 20 Japanese dive bombers head for a U. S. battleship cruising off the Solomon Islands. Aboard the surface ship, which bristles with automatic antiaircraft cannon, gun crews are ready for them. Eight minutes of ear-shattering fire—and the wreckage of 20 planes litters the sea.

More enemy planes are on the way, from their carriers. They try an up-to-date strategem. Dive bombers appear first, to make the battleship elevate all its guns. A moment later, torpedo planes swoop in from the side, barely skimming the water to launch their "fish." The attempted surprise fools no one. Again the battleship's guns loose an impenetrable screen of steel. Thrown off his aim, a Nipponese pilot lets go his torpedo too high, and it sails harmlessly over the warship's stern. Now U. S. planes from a supporting carrier are getting into the fight, and the remaining Jap aircraft flee. At terrific cost, they have scored only a single hit on the battleship, with a 500-pound bomb. It has landed on top of a turret, where a battleship carries some of its heaviest armor. So slight is the damage that, less than three weeks later, the battle wagon enters a major naval engagement and sends

WHAT WE NEED OUR BATTLESHIPS FOR
TO FIGHT ENEMY WARSHIPS
TO PURSUE AND DESTROY RAIDERS
TO GUARD IMPORTANT CONVOYS
BATTLESHIPS CAN NOT
OPERATE WITHIN RANGE OF ENEMY COAST-DEFENSE GUNS & AIR BASES

to the bottom four large Japanese warships with shells hurled from its big guns.

Just made public by the Navy, these new details of the battles of Santa Cruz and Guadalcanal, last October and November, offer an answer to the query of Al Williams, all-out plane enthusiast, "What have battleships done in this war, but sink?"

When Representative Carl Vinson, head of the House Naval Affairs Committee, expressed his opinion that the aircraft carrier had replaced the battleship as the backbone of the fleet, not a few persons agreed with him, and many went farther. Should we keep on building huge, costly battle wagons to serve as targets for bombs and aerial torpedoes? Aircraft carriers were a novelty in warfare. Their first achievements were spectacular successes, and airplanes showed that under favorable circumstances they could sink battleships—a fact that had never been doubted in well-informed circles. But carriers themselves are now proving as vulnerable as naval experts predicted before the war. And against air power, the superdreadnought is demonstrating its ability to strike back.

Why naval powers go on building battleships deserves closer looking into. First, just what are they for? Fighting enemy battleships is their specialty—and, in itself, reason enough for their necessity. Despite the heroic action of the U. S. cruiser *San Francisco*, which stood up to a Japanese battleship at point-blank range and crippled it so severely that other forces were later able to sink it, fortune cannot always be expected to favor brave men in outgunned ships. To keep the enemy from our shores, to carry the war to his own, and to destroy his fleet if it will come out and fight—or to keep it uselessly riding at anchor in port—our battleships must be more than a match for his.

Battleships have other important tactical uses. One or more may guard a task force, often confused by headline writers with a battle fleet. Actually the term means just what it implies—a group of ships assigned to a specific mission, such as protecting a convoy, seizing an enemy-held island, or running down a troublesome commerce raider.

Big guns of a battleship outrange those of all other craft, and its secondary battery of smaller guns disposes of close-range, hit-and-run torpedo attack by destroyers. One of the outstanding changes in battleship design, to meet the challenge of air attack, has been its phenomenal increase in antiaircraft fire power. Up-to-date capital ships carry sky guns ranging in size from the 20-millimeter Oerlikon, which blasts dive bombers with 400 quarter-pound shells a minute, up to the double-purpose five-inchers of the secondary battery, which can be elevated to bring down high-flying horizontal bombers. An in-between size, the 1.1-inch gun, lends itself especially to quadruple mounting. American design favors arranging the four barrels in a horizontal row, contrasting with the two-above-two

mounting of British pom-poms. Armor shields for the smaller guns, and turrets for the largest, now protect the gun crews from flying bomb splinters.

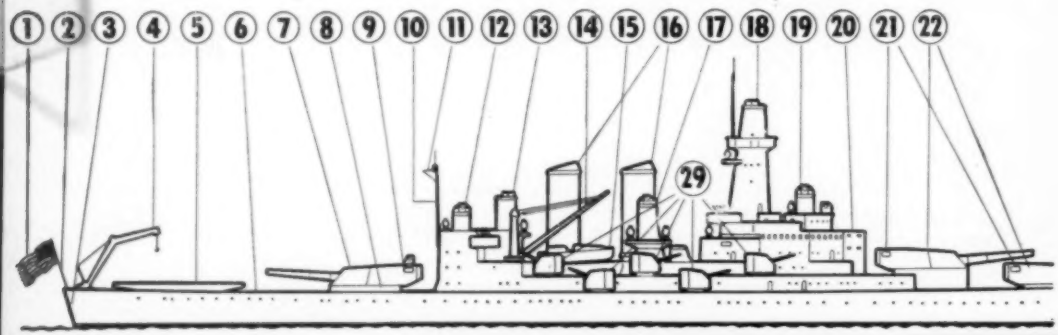
For all its power, critics may point out, a battleship today seldom travels alone. Actually it is too valuable to risk an ambush by enemy surface ships, or a torpedo hit from a lurking submarine. A pair of heavy cruisers and five or six destroyers provide about the minimum escort required for reconnaissance and anti-submarine screening. "Flak ships" with the sole mission of antiaircraft fire supplement a battleship's ability to defend itself, as do aircraft carriers. Without carrier support, capital ships cannot safely approach enemy air bases—a lesson learned by the British off Malaya at the cost of the new battleship *Prince of Wales* and the battle cruiser *Repulse*, sunk by only 40 Japanese planes.

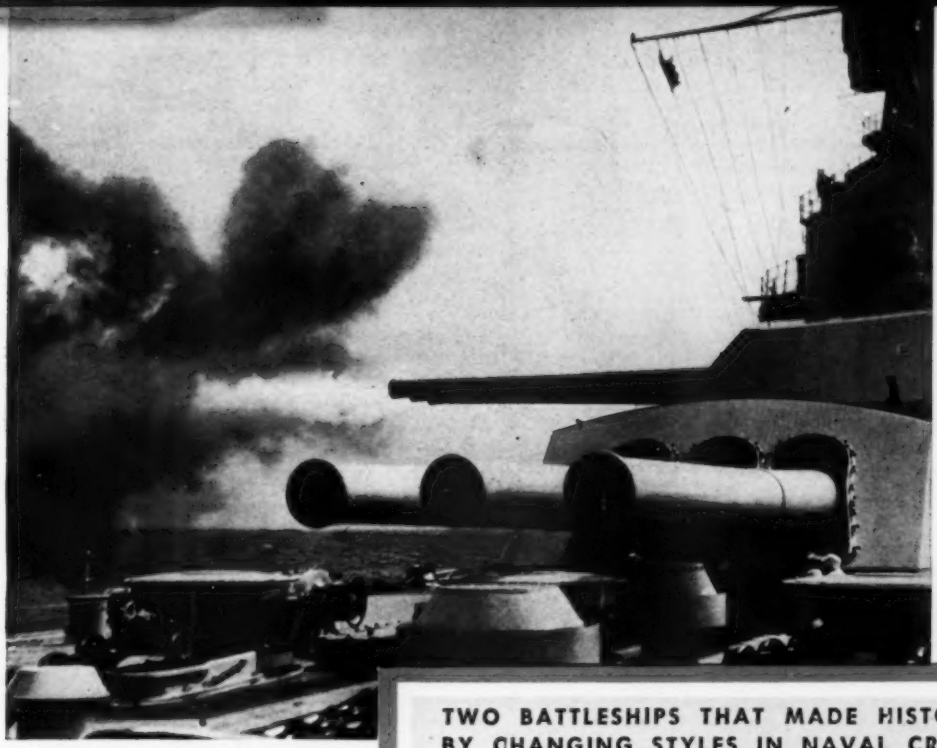
Of the tactical value of aircraft carriers, in fact, there can be no question, despite their high rate of mortality. In the Battle of the Pacific, at this writing, we have lost four—the 14,700-ton *Wasp*, the 20,000-ton *Hornet* and *Yorktown*, and the 33,000-ton *Lexington*. The toll of Japanese carriers has been considerably more severe. But so long as one remains afloat, it represents a ship of no mean striking power. Unique in naval history was our Midway Island victory in June of 1941—the greatest naval engagement since Jutland, fought almost wholly by opposing aircraft carriers! Fully aware of the need for ships of this class, the Navy has a substantial total of large ones under "rush" orders. In addition, a number of ships begun as 10,000-ton cruisers are being completed as converted aircraft carriers. Significant in this connection is the observation of one authority—that if the carrier were to replace any other class of warcraft, it would not be the battleship but rather the large cruiser. Because of a cruiser's comparatively light armor, it makes a far better target for carrier planes. At the same time, a carrier can take over the duties of reconnaissance formerly carried out by cruisers. This last, however, assumes favorable flying weather. In contrast, surface ships, including battleships, operate in spite of fog and darkness. Numerous night engagements have been a feature of the second world war. In these, the value of air power has been negligible, with planes kept grounded because of difficulty in finding and landing on their carriers.

At Pearl Harbor, Japan had demonstrated what carrier-based planes can do to battleships under practically ideal conditions. Taken by treacherous surprise, the motionless and weakly defended ships made almost as perfect targets as painted outlines on a practice range. Yet, of the eight battleships there, only one—the *Arizona*, about to become over-age—was wrecked beyond repair. The over-age *Oklahoma* capsized, but may

KEY POINTS OF A MODERN BATTLESHIP—THE U.S.S.

WITH all its intricate mechanisms of propulsion, fire power, and protection, a modern battleship is one of the most complicated machines ever built by man. Here are some of its key points, illustrated on the new 35,000-ton U.S.S. *North Carolina*. From stern to stem, they are: (1) Ensign. (2) Ensign staff. (3) Stern. (4) Seaplane crane. (5) Seaplane catapults. (6) Quarter-deck. (7) After turret, three 16-inch guns. (8) After barbettes. (9) Main battery range finders. (10) Mainmast. (11) Gaff. (12) After range finder, spotting glasses, and antiaircraft height finder. (13) After fire-control tower. (14) Boat crane. (15) Boats. (16) Funnels. (17) Port and starboard range finders, spotting glasses, and antiaircraft height finders. (18) Main fire-control tower. (19) Forward range finder, spotting glasses, and antiaircraft height finder. (20) Conning tower. (21) Main battery range finders. (22) Two forward turrets, three 16-inch guns in each. (23) Forward barbettes. (24) Forecastle.



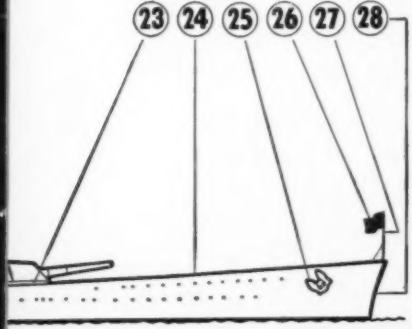


Big guns are the battleship's trump card, outranging all other guns afloat. Here the *North Carolina*, one of four new U. S. 35,000-tonners, lets go one of her turrets

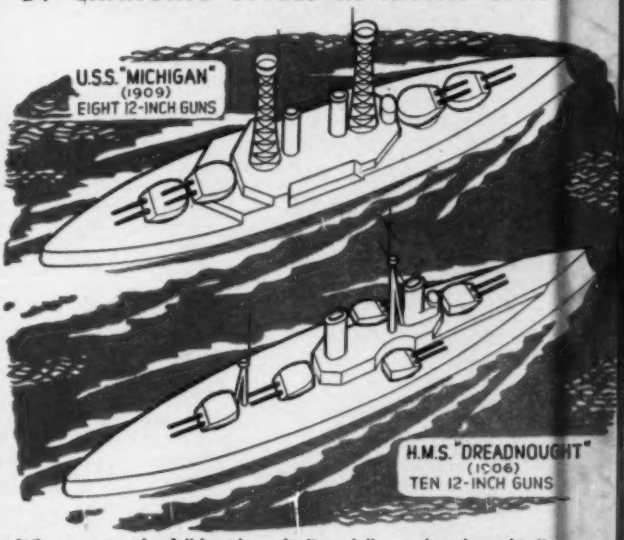
NORTH CAROLINA

(25) Anchors. (26) Union Jack. (27) Jack staff. (28) Bow. (29) Antiaircraft and secondary battery of guns.

Importance given to antiaircraft guns and secondary batteries reflects the changed conditions under which the battleship does its work and the recognition that it must be able to defend itself against new enemies.



TWO BATTLESHIPS THAT MADE HISTORY BY CHANGING STYLES IN NAVAL CRAFT



When we speak of "dreadnoughts" and "superdreadnoughts," we pay tribute to a vessel that began a new epoch in battleship design—H.M.S. *Dreadnought*, which in 1906 introduced the principle of a main battery consisting entirely of big guns. By a strange freak of fate, her most famous exploit was the ramming of a German submarine in the first World War. Another history-making ship was the U.S.S. *Michigan*, completed in 1909, which led the way in placing all main turrets along the center line so that the big guns could fire to either starboard or port

be salvaged. None of the rest suffered mortal injury, and damage to three was so slight that they were back in service within a few months.

Again, in the pursuit of the German battleship *Bismarck*, that mighty vessel showed its stamina. Even after planes had put its steering gear out of commission, the British battleships *King George V* and *Rodney* had to bombard it with about 700 shells before a cruiser could safely close in and sink it with torpedoes.

As to bombing attacks on battleships, few laymen realize that it is perfectly possible to see a bomb dropping, and change a ship's course quickly enough to dodge it. Naturally the feat requires split-second co-ordination of men and machines, but even big vessels can do it.

To counter this annoying habit, airmen have developed "pattern bombing." In this scheme, formations of planes attempt to drop their missiles in such a design that a ship cannot escape, no matter which way it turns. Some imaginary patterns, reasonable from a geometrical point of view, are reproduced here. Actual methods used by naval powers are strictly guarded secrets.

Compare bombing with shellfire, however, and some popular illusions about air power will evaporate. Penetrating a battleship's tough hide with a projectile takes plenty of velocity. Now, unlike a shell, a bomb depends solely upon gravity for its speed.

If it fell in a vacuum, a bomb would pick up speed without limit. Since it does no such thing, air resistance imposes a maximum or "terminal" velocity, which a bomb cannot exceed no matter how far it falls. No plane has ever reached an altitude sufficient to give a bomb this terminal velocity, but it has been calculated, and turns out to be about 630 miles an hour. A pilot of a modern pursuit plane could actually power-dive fast enough to outpace the bomb and fly under it before it hits its target! In practice, a speedy dive bomber looses a projectile that strikes, from 2,000 feet, at something like 300 miles an hour. Contrast these figures with the speed of a naval shell, hurled from the muzzle of a big gun at nearly 2,000 miles an hour, and still traveling at 1,000 miles an hour when it plunges upon the deck of an enemy ship beyond range of vision. Of course, it is possible to imagine an aerial bomb accelerated by a built-in rocket device. But a shell, equally adaptable to a rocket booster, would still be the more destructive missile.

For defense against hostile gunfire, a battleship carries by far the heaviest armor of any class of warship. The "belt" along its sides, shielding nearly all its vital parts from shells of flat trajectory, may measure from 14 to 16 inches in thickness. One or two armored decks, with a total thickness of as much as ten inches, resist the impact of high-angle shellfire and of air bombs. Turrets and their deep revolving mounts, called barbettes, receive heavy protection. In modern designs, more than 40 percent of a battleship's weight consists of armor. Compare the pitifully meager armor that an aircraft carrier can carry—its flight deck, the most important part to protect, would be impossibly top-heavy—and it becomes clear why battleships can slug it out while carriers go down.

Formerly all armor plate more than four inches thick was forged, a time-consuming process. One American plant now turns out armor for battleships and other warcraft eight to 10 times as fast, by rolling it on the world's largest plate mill. Some of the slabs weigh more than 50 tons apiece, and measure up to 195 inches in width.

Hit a battleship below the belt—in other words, under the side armor, which extends only a short distance from the water line toward the keel—and you will have struck its most vulnerable spot. Because of the hammerlike blow with which water transmits an explosion, a near miss by an air bomb fused for delay action can inflict serious hull damage. Mines and torpedoes, both now carried by airplanes, offer added danger. Even a single torpedo hit means an eventual trip for repairs. Though still afloat, a badly damaged ship may be slowed enough to become the prey of submarines, which could not catch up with it otherwise.

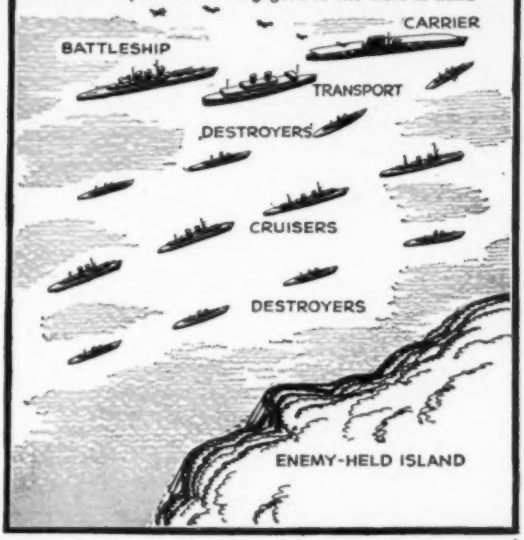
Many ingenious schemes have been applied to minimize underwater damage. One plan is to make the outermost compartment of the battleship a false hull or "blister," leaving it empty. In this idea, the blister explodes the torpedo. Compressible air, within, absorbs some of the force of the explosion and evenly distributes the rest. The inertia of liquid in inner compartments helps their bulkheads to take up more of the shock. Since a battleship's hull is large enough to be highly subdivided into watertight compartments fore and aft, it can take a good many torpedo hits and remain in action.

Concerning the increased peril brought about by aerial torpedoes, it has become traditional that each innovation in naval weapons has promptly been countered by a means of defense. Magnetic mines, for example, lost their terror when ships were equipped with degaussing cables.

In the evolution of battleships, both Britain and America have been pioneers. Two vessels in particular have made naval history. H.M.S. *Dreadnought*, the prototype of its class, introduced in 1906 a main battery

THIS IS A TASK FORCE

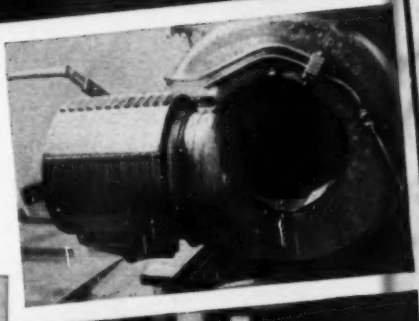
ITS MISSION IS to carry out a specific task, such as capturing or bombarding an island held by the enemy, protecting an important convoy, or running down a hostile surface raider. The battleship lends the power of its big guns to the work in hand



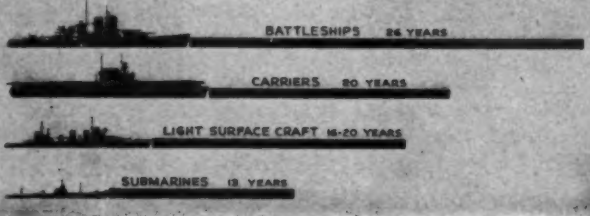
THIS IS A BATTLE FLEET

ITS MISSION IS to meet and destroy the main naval strength of the enemy in a pitched battle. A fleet action is basically a slugfest between the battle wagons, the other vessels screening their own battleships and annoying the enemy's

U.S.S. OREGON, famous for her dash around South America in the Spanish-American War, had 13-inch guns that made her one of the mightiest ships of her day. Photo (courtesy of Meier and Franks) shows her on the day after Santiago. When she was demilitarized for arms limitation, locking mechanisms of gun breeches (right) were destroyed and propeller shafts were cut in two, as seen at the lower right



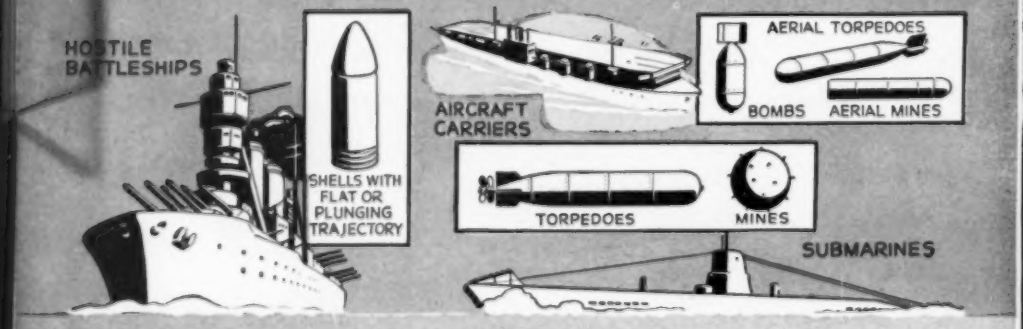
HOW LONG DO NAVAL VESSELS LIVE ?



HOW THE MODERN BATTLESHIP

FRIENDLY CARRIER PLANES
ANTIAIRCRAFT GUNS
ANTIAIRCRAFT MACHINE GUNS FIGHT OFF LOW-FLYING PLANES
MAIN BATTERY FIRES AT ENEMY SURFACE CRAFT
FRIENDLY CARRIER
5" LOW-LEVEL FIRING
WRECKAGE OF ENEMY E-BOAT

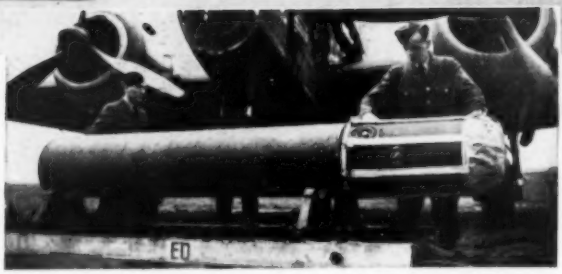
THE BATTLESHIP'S ENEMIES AND THEIR WEAPONS

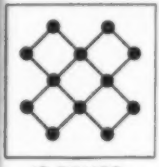


ANSWERS ITS ENEMIES
ENEMY DIVE BOMBERS
ENEMY HORIZONTAL BOMBERS
LARGE ANTIAIRCRAFT GUN BLASTS HIGH-FLYING BOMBERS
ENEMY TORPEDO PLANES
5 SHELLS RAISE GEYSERS OF WATER TO BLOCK TORPEDO PLANES
FRIENDLY ANTIAIRCRAFT SHIP GIVES SUPPORT AGAINST PLANES
FRIENDLY DESTROYER - PART OF SCREEN OF DESTROYERS & CRUISERS

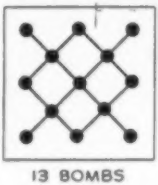
THE AIRPLANE VS. THE BATTLESHIP

Aerial mine layers, like the British Hampden seen in flight above, add a new peril for the battleship. At the right, a mine is ready for loading at an R.A.F. base. Below, a flying boat drops its deadly aerial torpedo

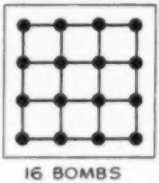




12 BOMBS



13 BOMBS



16 BOMBS

PATTERN BOMBING

Since a battleship sometimes can dodge a single bomb, formations of attacking planes lay geometrical patterns to block escape

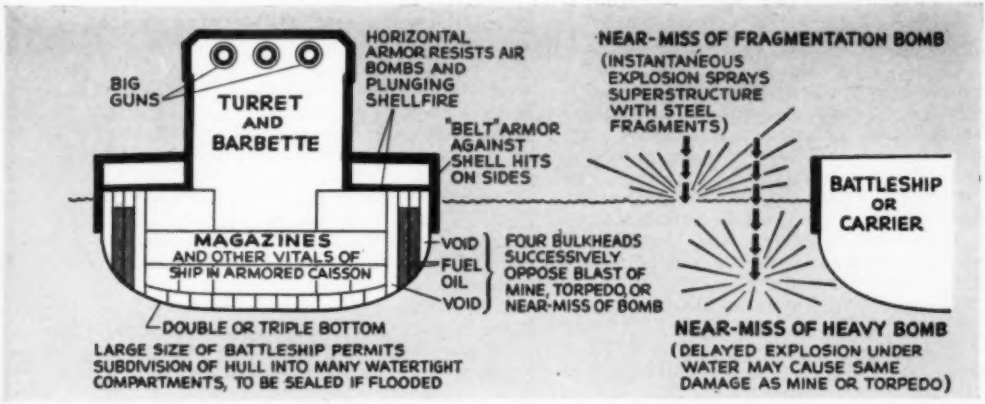
ANTIAIRCRAFT GUNS like these 20-mm. Oerlikons aboard a big battle wagon are a new feature of the modern capital ship. A larger automatic, the 1.1-inch caliber, is often mounted by our Navy in groups of four as a multiple pom-pom, or "Chicago piano"

consisting entirely of big guns. Three years later, the U.S.S. *Michigan* set the style for present-day arrangement of all main turrets along the center of the ship, permitting the full force of a broadside to be delivered either to port or starboard. Practically all modern men-of-war follow these basic principles, even though today's capital ships dwarf the earlier ones.

Other American innovations include the first steam warship; the first screw-propelled man-of-war; the first ship-based take-off and landing of a plane; and the supposedly modern art of zigzagging. Flying in the face of naval tradition before that time, the maneuver was introduced to dodge shellfire as early as the Spanish War.

One of the most powerful warcraft of her time was the 10,000-ton battleship *Oregon*, famed for her record-breaking dash around Cape Horn in time to help destroy the Spanish fleet at the Battle of Santiago in 1898. The four 13-inch guns of her main battery were the most formidable in existence. Now, after years of honorable retirement, the *Oregon* is going to serve her country again. The historic vessel will be scrapped, and reborn in mighty fighting ships called for by our huge construction program.

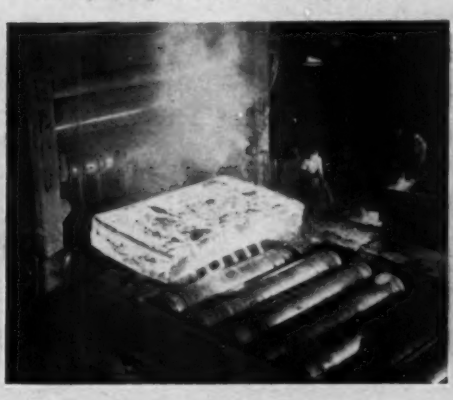
Since naval designers attain the best com-


BIG GUNS
TURRET AND BARBETTE
HORIZONTAL ARMOR RESISTS AIR BOMBS AND PLUNGING SHELLFIRE
"BELT" ARMOR AGAINST SHELL HITS ON SIDES
MAGAZINES AND OTHER VITALS OF SHIP IN ARMORED CAISSON
VOID
FUEL OIL
VOID
FOUR BULKHEADS SUCCESSIVELY OPPOSE BLAST OF MINE, TORPEDO, OR NEAR-MISS OF BOMB
DOUBLE OR TRIPLE BOTTOM
LARGE SIZE OF BATTLESHIP PERMITS SUBDIVISION OF HULL INTO MANY WATERTIGHT COMPARTMENTS, TO BE SEALED IF FLOODED
NEAR-MISS OF FRAGMENTATION BOMB
(INSTANTANEOUS EXPLOSION SPRAYS SUPERSTRUCTURE WITH STEEL FRAGMENTS)
BATTLESHIP OR CARRIER
NEAR-MISS OF HEAVY BOMB
(DELAYED EXPLOSION UNDER WATER MAY CAUSE SAME DAMAGE AS MINE OR TORPEDO)

HEAVY ARMOR PLATE PROTECTS THE BATTLESHIP'S VITALS

Because it is built to stand up under plunging shell-fire, the battleship is less vulnerable to bombing than is the carrier with its necessarily light flight deck. Near misses of heavy delayed-action bombs, exploding in the water below the belt-armor level, can damage a battleship more than direct hits on deck

Deck and belt armor plate, once made by a slow forging process, is now produced ten times as fast by rolling on the world's largest plate mill



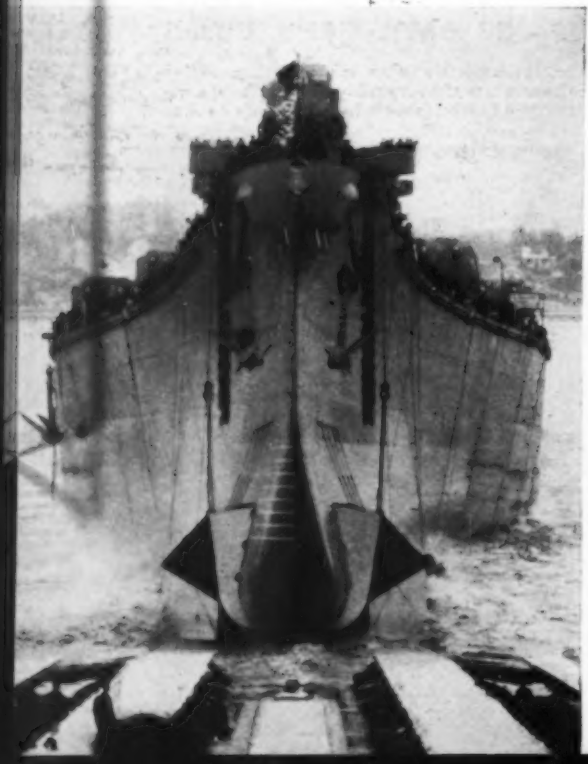
The thick slab of hot metal seen entering the mill at the lower left comes out as a much thinner plate, yet still thick enough to stop heavy projectiles

AT PEARL HARBOR, with every advantage, the Japs were able to ruin only one of eight battleships. Three were soon ready to fight again

promise between guns, armor, and speed in warships of great dimensions, battleships are reaching unheard-of size today. By now, although the Navy does not announce commissionings in wartime, four sister ships of the new, 35,000-ton *North Carolina* and *Washington* may reasonably be assumed to be in service. And the first two of five projected 45,000-tonners, the *Iowa* and *New Jersey*, have been launched.

This 45,000-ton figure, at least, was the size originally announced when they were laid down in 1940. More recently, the Navy has made it known that their design has been changed to incorporate results of lessons learned in the current war. Exact figures for their displacement are now a wartime secret. However, the *New Jersey* was said by the Navy to have a slightly greater tonnage displacement than her sister ship, the *Iowa*, when she slid down the ways into the Delaware River at the Philadelphia Navy Yard. She will be the heaviest battleship ever constructed.

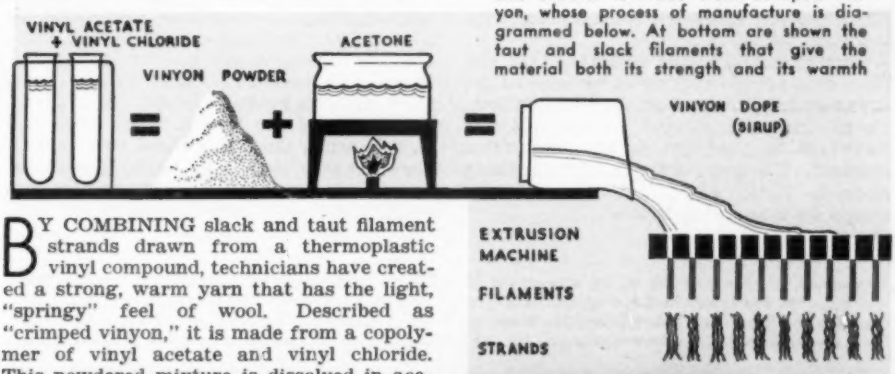
Some doubt exists about plans for a future 58,000-ton *Montana* class proposed some time ago. The Navy has announced no decision not to build them, but their construction may be postponed indefinitely, in favor of more urgent shipbuilding. Critics point out that the ships quite possibly might not be completed in time to see service in this war. Every increase in size imposes added difficulties in negotiating shallow channels, in finding suitable harbors, and in being dry-docked for overhaul and repair. Too, there may be a point at which a battleship becomes so huge and expensive that its loss from any cause would be a national calamity. Perhaps two smaller battleships, built at something like the same total cost, would be more useful than the big one. Whatever we do build in battleships, however, seems beyond the power of aviation extremists to criticize successfully.



Symbol of America's faith in the battleship is the mammoth *New Jersey*, one of five projected 45,000-tonners, here seen as she slid down the ways. A sister ship, the *Iowa*, also has already been launched

Wool Substitute Found in Vinyon

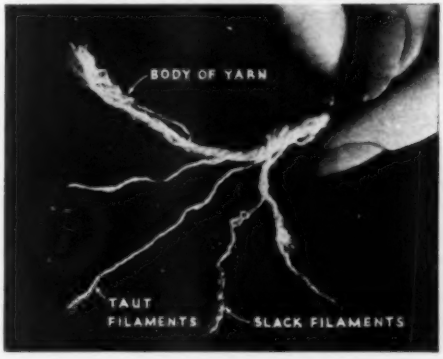
This sweater is made from Crimped Vinyon, whose process of manufacture is diagrammed below. At bottom are shown the taut and slack filaments that give the material both its strength and its warmth



BY COMBINING slack and taut filament strands drawn from a thermoplastic vinyl compound, technicians have created a strong, warm yarn that has the light, "springy" feel of wool. Described as "crimped vinyon," it is made from a copolymer of vinyl acetate and vinyl chloride. This powdered mixture is dissolved in acetone under heat, and the resulting sirup—or "dope" as it is called in the trade—is squeezed through the tiny holes of an extruding machine similar to the one used in the manufacture of rayon. When they come into contact with the air, these sirupy streams solidify into extremely tenuous filaments, each of which is only a fraction of the thickness of a human hair. These filaments are then collected into bundles and drawn out at different tensions so that some of the filaments are taut while others are quite slack. When wound, they form a yarn very similar to that found in heavy Shetland. The curvature in those filaments that have been allowed to remain slack creates the air pockets that are the secret of the material's excellent heat-insulating properties.

Outstanding feature of this new material is that it is impervious to many of those things that so quickly take the life out of other materials—food and perspiration stains, for instance, or the alkalies and acids used in washing and dry cleaning. For this reason, it is considered ideal for children's wear. Another feature is that because it is shrinkproof, it can be washed in cold water. And lastly, being water-resistant, it can be made to dry quickly by giving it a thorough wringing out. It does, however, have one drawback—a low boiling point—which means that it can't be ironed or otherwise exposed to extreme heat.

Crimped vinyon is not yet ready for the public, but it probably will be by the time the war ends. In the meantime, research workers are endeavoring to make it with thinner filaments, as the present 10 or 12 strands form a comparatively bulky yarn.



Reach and Punch —THAT'S OUR 155-MM. HOWITZER

The piece rolls along behind its prime mover, a big four-ton Diamond-T truck, which also carries the men

By JOHN H. WALKER
Photographs by William W. Morris

BLUNT, businesslike, and snub-nosed, the U. S. Army's 155-millimeter howitzer is a fast-moving medium artillery piece with a wicked punch.

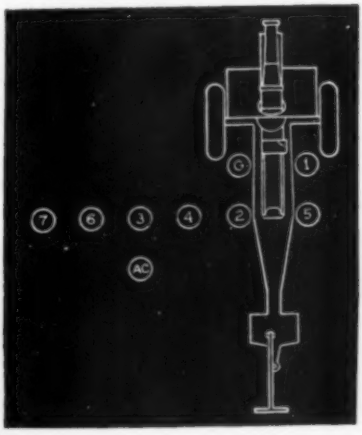
Unofficial Army talk indicates that the 155 was a particularly mean surprise to the Japanese infantry and artillery on Bataan, where our outnumbered troops put the howitzers to good use during that bitter struggle. The guns were in there barking again in North Africa, and wherever our troops have moved in force.

Like all guns of the howitzer type, the 155 has the advantage of extreme elevation of the barrel, enabling it to lob shells in a high arc over intervening hills.

It fires a projectile of slightly under 100 pounds, with the propelling charge loaded separately. The base charge can be combined with one to six powder increments, to fire into zones of increasing range. Maximum effective range is around 10,500 yards.

Not one of the newest weapons in the U. S. arsenal, the 155 is based on a Schneider (French) design of 1918. The model was an extremely efficient one, and the gun itself, tube and breech, has been little

Ready to fire, the gun tilts up its nose at the high angle characteristic of howitzers. Firing positions of the crew are shown in the diagram. The gunner (G) lays and refers the piece. No. 1 closes the breech and fires. Nos. 2 and 5 load the piece, while No. 3 cleans and fuses the projectiles. No. 4 carries ammunition. No. 6 prepares charges. No. 7 helps with ammunition, under ammunition corporal (AC)



On fair roads, the 155 can be moved at 50 miles an hour. Picturesque names, such as "Jap-Slapper" and "Avenger," are bestowed on the guns by their crews

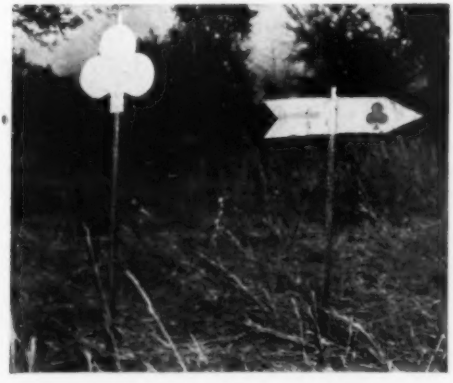
Canvas boot covering gun muzzle in transit carries a glass reflector for traffic safety. On top of it is a tail light powered from the truck, for blackout use

changed. Certain modifications have been introduced, especially to make the weapon move faster and handle more easily on the road.

A battery of 155's, thundering along the road to an assigned position, can halt, move the guns into place, and open fire in less than eight minutes. In action the normal rate of fire is three rounds a minute for each howitzer. They can be fired considerably faster in an emergency, but the barrel tends to heat up at an excessive rate.

In normal operations the 155's are used as divisional artillery, supporting the general line of the division wherever their power is needed. They are thus medium weapons between the lighter 105-mm. gun-howitzers, which characteristically would be operating with the division's combat teams, and the much heavier 155-mm. rifles (equivalent to six-inch naval guns) which probably would be serving as army corps artillery.

Signs placed in advance by an officer mark the position of each gun and its direction of fire. Each of the four pieces in a battery is designated by a playing-card symbol (club, heart, spade, diamond)



The most common assignments of the 155 howitzers are counter-battery fire or interdiction and harassing fire. That is to say, the shells are tossed at enemy artillery positions, at supply dumps and strong points, or at highways and crossroads where heavy enemy traffic is passing. The objectives of fire are not only to smash at hostile installations, vehicles, and personnel, but also to make whole areas of terrain, roads, or populated districts at least temporarily unusable for enemy forces.

The men who serve and care for these guns speedily develop a remarkable affection for their husky, ugly-efficient charges. As one sergeant explained:

"We can reach! And where we reach, we got power!"

Most American crews soon endow their guns with personality, and with picturesque names painted on the shields. One battery

proudly emblazoned these titles on its four guns: "Jap Slapper," "Avenger," "Nazi Nightmare" and "Rising Sun Sinker."

Other symbols painted on the guns have a more practical purpose. Any four distinctive symbols would do for the four guns of a battery, but the traditional heart, diamond, club, and spade designs seem to have been made to order for the purpose. Each gun has one of these stenciled on it. When the battery is moving up to a new zone, an officer precedes it, selects a suitable firing position for each gun, and at each of the four points sets up a small standard carrying the corresponding symbol and an arrow pointing in the direction in which the gun should be pointed.

When the howitzers arrive they are hauled to the indicated spots and wheeled into position, pointing to their targets. The men of each gun crew then hop down from

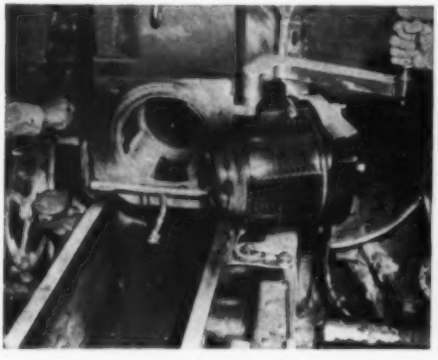
When the piece is uncoupled from the truck, its heavy spade trail is driven deep into the ground

the prime mover, uncouple the piece, and prepare to go into action, sinking the heavy spade trail into the ground. It is understood that the Army has been experimenting with a new type of split trail for this howitzer, but none has so far been officially adopted.

The gunner is responsible for laying the piece. Here he is sighting into the scope for traverse . . .

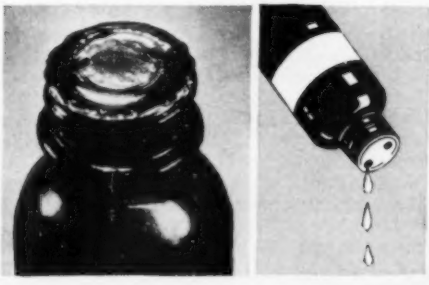
. . . and here he uses the gunner's quadrant, set on the breech, to measure the angle of muzzle elevation

An operating handle opens the breech. The 100-lb. projectile and the propelling charge are separate



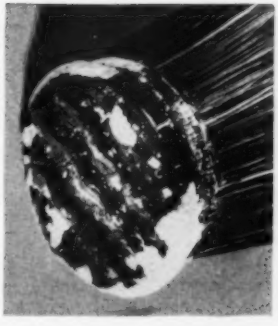
With the breech closed, the lanyard is pulled to fire the piece. Propelling charge varies for range

LOCKHEED CONSTELLATION, largest and fastest land-based transport plane ever built, can carry 55 soldiers plus a crew of nine across the continent nonstop in less than nine hours, flying above the weather at 20,000 to 35,000 feet. Four 2,000-hp. engines give it more speed than a Zero fighter. The sharklike body carries a triple tail which not only cuts down over-all height but also gives added control and safety.



TO REPLACE MEDICINE DROPPERS, which have become scarce along with rubber, E. R. Squibb & Sons is using a drop-dosage bottle for some of its products. It is a version of the two holes in the top of a condensed-milk can long known in American kitchens. The bottle is sealed under its cap with a new type of cellulose film that has two holes punched in it at opposite edges. For use, the bottle is tilted and the contents are dropped out of either of the holes at a rate which makes it easy to judge the amount of liquid that has been dispensed.

PLASTIC SHAVING BRUSHES requiring no critical rubber for their bristle settings have become regular issue in the U. S. Army to conserve strategic materials for more vital war needs. An additional saving has been made in eliminating the customary brass ring at the base of the bristles without affecting the permanence of the settings. The plastic has proved its worth in tests, resisting cracking, bending, and disintegration, and withstanding immersion in water heated to 160 degrees F. Two million of the brushes have been ordered.



Bristles in this Army shaving brush are set in plastic, as shown above, to save rubber. Assembled, at right, the brush appears like any familiar type

WAR TURNS AN AGRICULTURAL COUNTRY INTO AN ARSENAL AS

Canada GOES INDUSTRIAL

By JAMES MONTAGNES

CANADA, for three centuries largely dependent upon its fields, forests, and streams for livelihood, has industrialized itself in the last three years. The war emergency made it necessary, but Canada will emerge from the war industrially minded and industrially equipped.

Almost 1,000,000 of Canada's population of 11,500,000 are employed in essential war industries and 650,000 more are in Canada's armed forces. Canada, almost an industrial void in September, 1939, has since then absorbed war orders aggregating more than $6,000,000,000, and will spend $3,500,000,000 this year on the war, a sum about equivalent to the entire national income of the last peace year.

Almost every industrial plant in the country has been put into war production and dozens of new plants, put up on an acreage basis, have sprung up. Prior to 1939 Canada imported all the materials necessary for her small armed forces. The fateful year 1939 found it not only short of factories, but short of machines to build the tools with which to turn out war supplies. There was a shortage also of mechanical experts.

There were no steel mills producing armor plate. Tanks which the United States had built for the first World War had to be imported for the early training of the Canadian tank crews. The Canadian Navy consisted of six destroyers and six mine sweepers. Tool-making machines were imported. Mechanical experts were borrowed. Steel mills were equipped to turn out armor plate. Not only the automotive industry, but all industry possible was converted to war use. A laundry, converted in peacetime to an elevator factory, underwent its second major operation and now is turning out great quantities of two-inch smoke-bomb throwers.

Canada started the war with the idea of becoming self-sufficient. She has just about realized her ambition, though peak production will not come for some months yet.

The Canadian Navy has more than 500 vessels and they are Canadian-equipped from steering gear to range finder. The Canadian airplane industry, which turned out about 40 craft a year in peacetime, sends out 400 planes a month.

Except for battleships and the largest guns, Canada's war industries not only supply her war needs, but also turn out a large surplus for her allies. Thirty percent of Canada's war output suffices for her own armed forces. The rest goes to Russia, to Great Britain, to the United States. Among the United Nations, only the United States and Great Britain surpass Canada in war production.

From coast to coast, Canadian farmlands have sprouted factories—shell-filling plants, chemical plants, war shops of all kinds. C. D. Howe, Canadian Munitions and Supply Minister, said recently that more than $100,000,000 had been spent on construct-

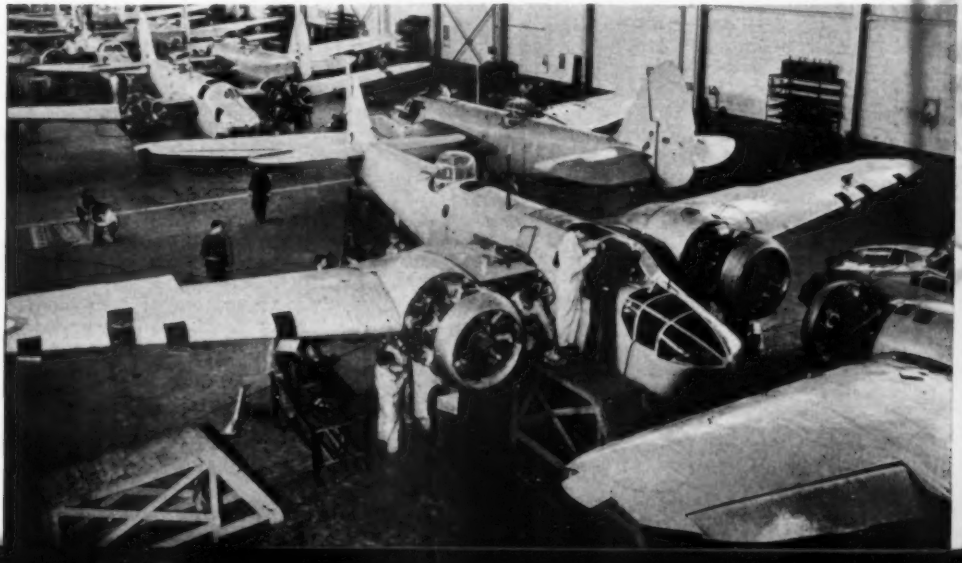
Canada's Valentine tanks, used so effectively by the Russians, are built in a locomotive plant, as witnessed by the engine bells in foreground. Below, Bolingbroke bombers are shown being assembled

ing and equipping chemical plants alone.

An elevator manufacturer has converted his plant to the manufacture of the Bofors antiaircraft gun, the bell-mouthed fast-firer which stands guard in the United States as well as in Canada and travels far afield to shoot down its prey. Canada was able to export these guns, capable of firing 140 shots a minute, to the United States before this country was equipped to turn them out.

A soup-canning plant is making ammunition. A marine engine factory turns out not only ships' boilers but also the Boys antitank guns which can send a .55 caliber, armor-piercing projectile into the most sensitive and best protected parts of a tank. Browning aircraft machine guns, automatic rifles, and other weapons also are coming from the boiler factory.

The automobile factories of Canada, subsidiaries of American companies, are mak-



Trailers for 25-pound guns are now being turned out in ever-increasing quantities by a Saskatchewan plant formerly engaged in manufacturing road-work machinery. The trailer, shown here between tractor and gun, carries three trays of ammunition, spare gun parts, and also an extra tire

ing 100 different types of mechanized fighting vehicles, including mobile machine shops. Locomotive shops produce tanks at the rate of three a day. A shoe manufacturer is making naval guns.

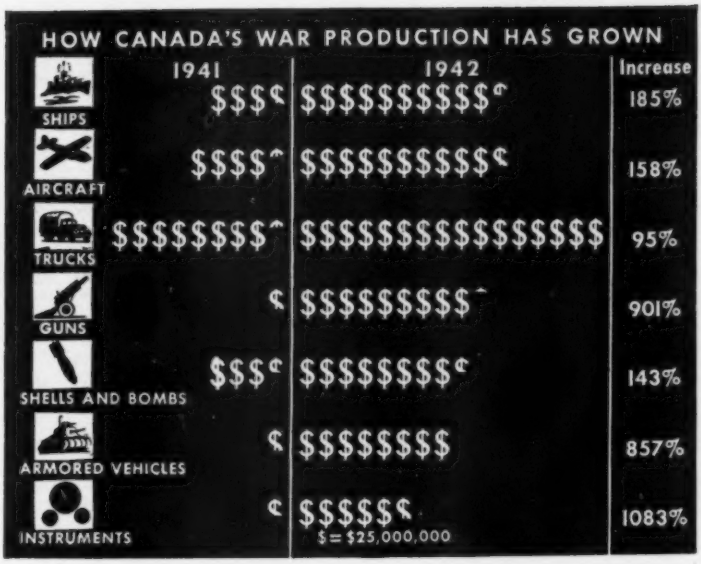
Gunsmithing is not a science that is mastered in a short time. The skill and accuracy it demands is acquired only after years of patient practice. Canadian gunsmiths were few when Canada went to war. Only once before—during the first World War—had Canadian industry been called upon to make guns, and then it made only infantry rifles. With few experts to call on, and only blueprints and working models to start with, Canada set out to make guns in 1939. There were also the handicaps of a lack of machine tools, and a lack of raw materials in the form of steel and castings. Slowly these were overcome. Plants were converted, machine tools were obtained by painstaking hunting throughout Canada and the United States, men and women were recruited for the new industry and patiently trained to do the work.

In last October alone, Canada's production of small arms was almost double its entire production in 1941. Twelve types of small arms, 12 types of guns, and 16 types of gun carriages were coming out of Canadian shops. Besides the Bofors guns, the Browning aircraft machine guns, and the Boys antitank rifles, 25-pounder field guns of the most modern type were being produced by Sorel Industries, Ltd., at the rate of 50 a month at $25,000 each and the powerful 3.7 antiaircraft guns, which have several thousand parts and weigh as much as a city bus, were coming off the assembly line at the rate set.

Canadian manufacturers also were turning out the four-inch naval gun, the 12-pounder naval gun, the two-pounder naval gun, the .50 caliber Vickers naval machine gun, the two-inch and three-inch trench mortars, tank bomb throwers, naval depth-charge throwers, Lee-Enfield rifles, Sten submachine carbines, and Bren automatic machine guns.

In machine tools, Canada did another about-face. In 1939 she needed them desperately. Since 1942 she has been exporting them to Great Britain and the United States.

Nine types of planes are in production in Canada, including the Curtiss Hell-Diver, 1,000 of which are being built for the United States Navy. Another is the British Mosquito fighter-bomber, a speedy plane which was on the "secret list" until recently. Canadian plants also are turning out the four-engined Lancaster, a heavy bomber whose block-busters have destroyed both German and Italian industrial plants. Hurricanes, Catalina PBY flying boats, and the Bolingbroke and Anson twin-engined bombers also are in production in Canada, as well as trainer planes. Propellers of both metal and wood are turned out in such numbers that the United States has been importing them. The Canadian aircraft industry, which employed about 1,000 persons before the war, now keeps more than 55,000 men



and women busy. To help the aircraft program, Canada has, since the start of the war, built the largest aluminum plant in the world to help supply both her own war needs and those of the United Nations. The current capacity of this enormous plant is already greater than the world's total output of aluminum during the year 1939.

Canada had never made any optical glass before she entered the war. Imports from Great Britain, Germany, and the United States had been relied upon to meet her needs. A large part of these imports were cut off just at the moment that Canada was going to need the glass for range finders, gunsights, periscopes, and other instruments. The government-owned Research Enterprises, Ltd., was set up in Toronto to meet the emergency and within eight months of the start of the project the first optical glass was produced.

In a relatively short time the plant not only was meeting Canada's needs, but also was sending its instruments to Canada's allies. Its field soon was widened and it is now manufacturing scientific equipment of various sorts, including communications instruments and articles which still are on the "secret list," such as radio locators. The plant turns out optical instruments of all kinds; navigating instruments for planes, ships, and fighting vehicles; and fire-control instruments for the navy.

British shipyards used to supply what ships were needed for Canada's ocean and Great Lakes commerce, and Canada's shipbuilding efforts were confined largely to river, harbor, and fishing craft. Canada now has 21 major shipyards and 58 smaller ones. Canada is building 300 cargo ships of 10,000 tons and a number of 4,700-ton cargo vessels, utilizing the prefabrication method. Canada also is turning out destroyers, corvetes, mine sweepers, submarine chasers, and patrol boats of various types. At least one of the corvettes was built for the United States. In the latter part of 1942, Canada's ship-building program, according to Humphrey Mitchell, Canadian Labor Minister, surpassed that of Great Britain.

Canadian tanks, both 18-tonners and 30-tonners, have been fighting on the Russian front for months and have received high praise from the Russians. Both Canada and Great Britain depend upon the product of new mercury mines which have been discovered and developed in Canada since 1939. A new magnesium production method, developed in Canada's national Research Council by Dr. L. Pidgeon, is in use in the United States, and new iron-ore deposits in the Dominion are furnishing their quota of the North American output.

While in the throes of this mushroom industrial development, Canada has kept her agricultural production at a record height and has been able not only to feed herself, but to export to Great Britain, Russia, and other countries. It is her intention to have agriculture and industry march abreast in peace as in war.

War Drafts the

WELDING ANSWERS THE CALL FOR SPEEDIER BUILDING OF SHIPS, TANKS, AND PLANES

By RUSSELL C. HOLSLAG

WEIRDLY garbed in helmet and gauntlets, guiding a hissing flame or a spitting arc, the welder is a picturesque figure in the complex pattern of war production. And in its results the work is as spectacular as the worker, for the man (or woman) in the mask is one of the foremost soldiers on the industrial front.

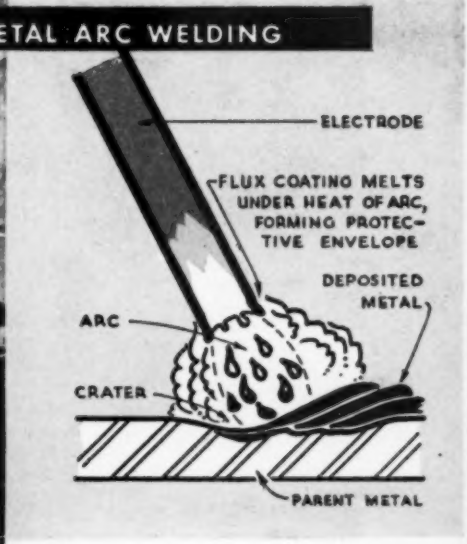
Welding has a big job. One of the speediest methods for the fabrication of metal structures, it reached the stage of advanced development at just the critical moment to answer the demand for ships, tanks, and planes to be built faster and sturdier than they had ever been built before. Under this stimulation it has made advances that were not even thought possible, and has so increased the scope of its operations that it cannot fail to remain as a permanent method of fabrication in the era of world building that is to come.

Welding, which uses gas and electricity as its two main sources of heat, consists of melting together two adjacent metal edges and of providing additional metal as filler. The gas welder uses an intense, jetlike flame emanating from a nozzle in which oxygen is mixed with acetylene, hydrogen, petroleum gases, and others, under pressure. Depending on the volume of the gases and the pressure to which they are submitted, the gas torch can develop a heat approximating 3,000 degrees centigrade. In gas-torch welding, the filler metal is supplied by melting a separate rod whose tip is constantly fed into the welding area.

In electric welding, however, the rod tip itself supplies the necessary heat—in the form of an arc drawn between the work and the end of the rod, which is actually an electrode. Here again the melting electrode provides the filler, the rod tip, of course, always being at the hottest part of the welding area. The arc, which is "struck" by touching the tip of the rod to the work and then drawing it away a short distance,

ELECTRIC WELDING DERIVES ITS HEAT FROM AN ARC

Photo from Office of War Information



Deck units of a new Liberty ship are shown at left being arc-welded. The electric arc that jumps between the end of the rod and the basic material produces a heat of 6,000 degrees C.

MAN IN THE MASK

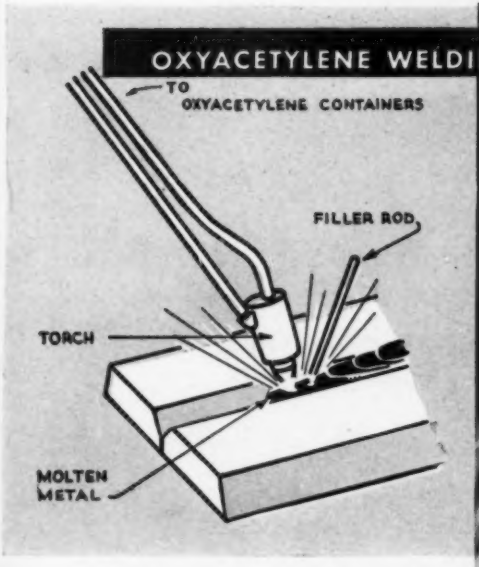
is a flexible, gaseous conductor that becomes intensely hot as the heavy current passes through it. The rod is generally coated with a flux that melts or burns under the intense heat and surrounds the arc with a protective envelope of inert gas and slag. It also aids the filler to merge with material being welded. Because of its temperature, 6,000 degrees centigrade, and the active effect of the high-amperage current, arc welding achieves a speed and penetration that have made it highly desirable in rapid fabrication.

One now hears much about the "art" of welding. The term is appropriate, for the difference between a good weld and a bad one depends on the instinct or "feeling" that the operator develops. He handles his welding rod as a painter does his brush, but with this important difference: the excellence of a painter's work is apparent from a surface inspection, whereas the welder's skill must be underneath as well as on top. In short, the molten metal must be correctly deposited at the very root as well as on the surface of the weld in order to form a permanent, homogeneous bond.

To utilize every last ounce of efficiency and speed that modern welding can bring to large-scale production, a new science of jig and fixture designing has been born. Because welded metal can most easily be deposited downward, special "positioners" are built to hold the work so that all welding seams can be brought approximately to a horizontal position, and also so that the welding can proceed almost continuously.

In ordinary arc-welding practice, a special handle or holder is used which grasps an electrode about 14 inches long. Current is brought to this handle through a flexible cable and, whenever necessary, a new electrode is inserted by releasing the pressure on the spring jaws. The trick of using a continuous electrode for hand welding has been applied by one company to speed up production. The current is fed through the welding wire itself, making unnecessary the heavy cable connection through the handle. This wire is fed from a coil above the operator's head. When the length of wire from the handle jaws to the arc gets uncomfortably short, the operator simply releases the spring grip and slides the jaws farther

THE GAS WELDER USES AN INTENSE, JETLIKE FLAME



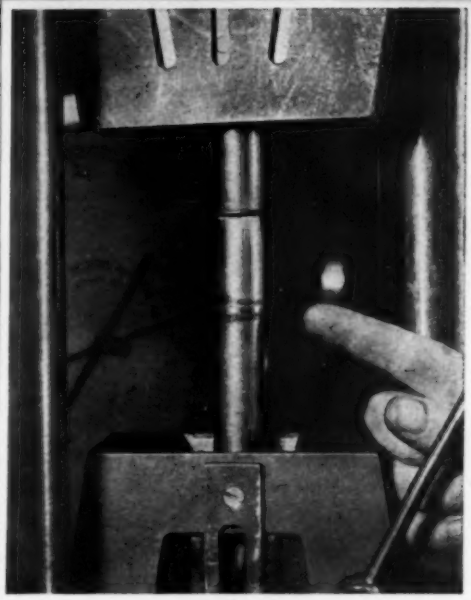
Welding a steam pipe with a gas torch is shown at right. The filler rod in the operator's left hand is melted by the jetlike flame of the torch, which creates a heat of only 3,000 degrees C.

up along the wire. A great deal of time otherwise consumed in changing electrodes is saved by this simple expedient.

Very often the question is asked, "If welding is so universal in its application, why do we not see more seam welding on thin metal work, such as is used in airplanes and the like?" The answer lies in the intense, concentrated source of heat which is produced by the welding arc. The metal must have sufficient "body" to absorb this intense heat, else it may simply burn through without melting. Softer metals also have critical melting points, to which welding heats must be carefully adjusted.

Welding can also be accomplished through heat generated in the metal itself by its resistance to the passage of an electric current. Generally, the parts to be so welded are held together under pressure and the highest resistance is generated at the point where the two pieces are in contact. It is at this point that the greatest heat occurs, and thus the metal is made to melt and fuse together at the joint. "Spot welding" is perhaps the most familiar example of this action and is widely used for joining thin metal. The spot-welding machine incorporates two opposing electrodes which can be made to press against opposite sides of the work by working a manual or pedal control. Current is then automatically applied and the heat produced is sufficient to melt a small area at the point of contact between the two metal surfaces. Many effective and ingenious developments have been worked out in this field. One surrounds the electrode with a refrigerant to prevent overheating and speeds up production.

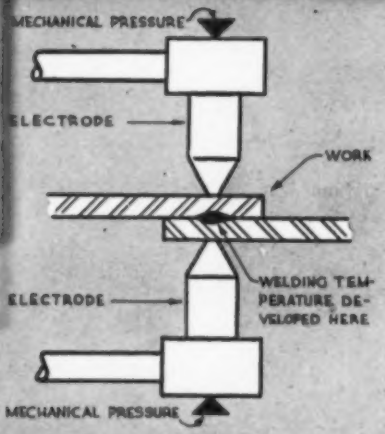
"Pressure welding" is similar in principle



FLASH WELDING

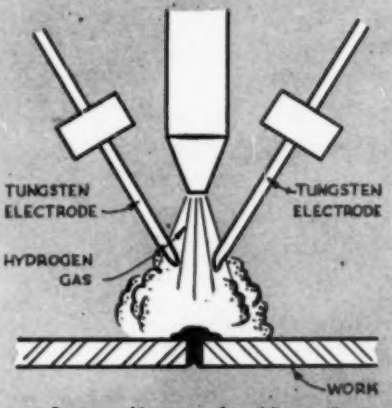
To determine the strength of the joint that had been flash-welded between two pieces of steel tubing, as shown in the photographs at the right, the tube was placed in the testing machine above and there subjected to a tensile strain of 100,000 pounds per square inch before it finally broke. But when it did, it parted not at the welded joint (indicated above by the pointing finger) but in another portion of the original tubing

SPOT WELDING



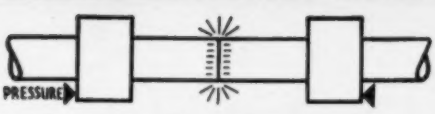
In this kind of welding, a heat sufficient to melt and fuse the metal is created in the metal itself by its resistance to an electric charge. Electrodes also press parts together

ATOMIC HYDROGEN WELDING

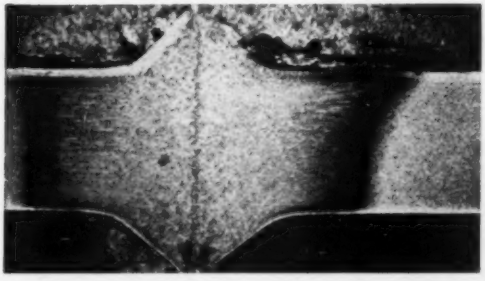


Because this type of welding will not "burn" metals, it is particularly well suited to thin metals and those with low melting points

To flash-weld the two parts of a steel tube, the parts are first placed in dies, and then secured by means of air-pressure clamps. Dies are then moved apart to allow for play of electric arcs

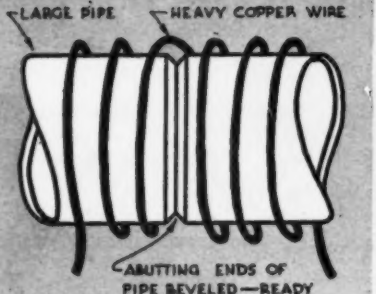


Here an electrical charge flowing across the gap between the two parts sets up a series of intensely hot arcs. Fiery display that is seen to result is caused by the flying off of burning particles

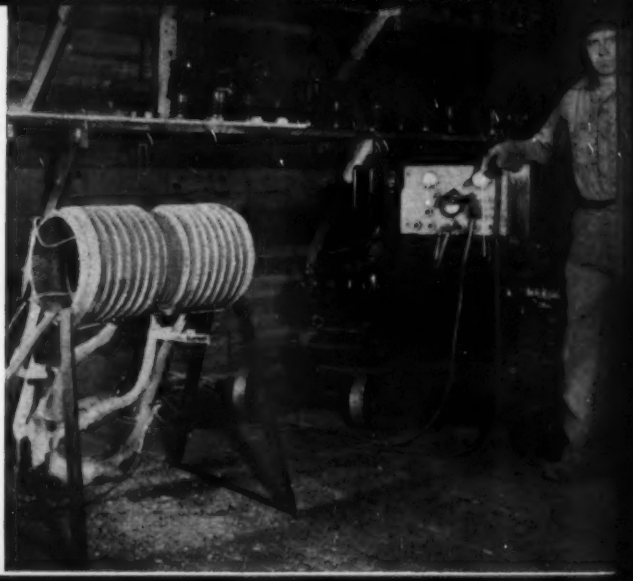


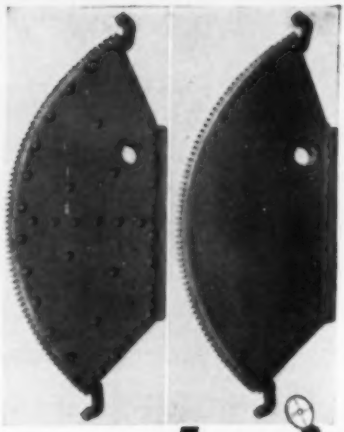
As soon as the heat from the arcs begins to melt the ends of the tubes, pressure is applied, and the hot tube ends are forced together. The photograph at left shows flash weld in cross section

PREHEATING HIGH-PRESSURE PIPES FOR WELDING

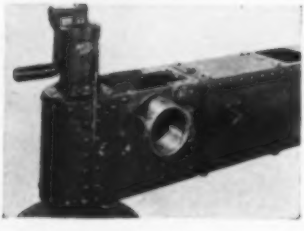


A high-amperage current in the cable makes the pipe hot enough to weld. Reduced current keeps the pipe from cooling too fast





At left, the elevating arc sector of the gun in its original riveted form and as it is now being welded. At far left, the same comparison is shown in part of one of the gun's outriggers



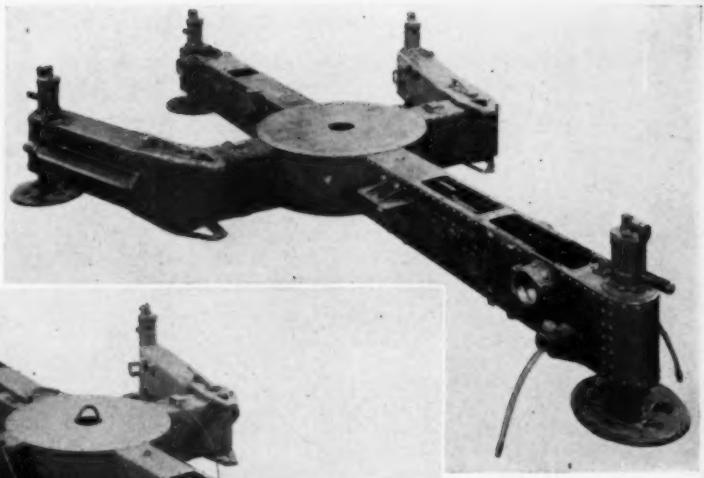
BOFORS GUN CARRIAGE IS NOW WELDED

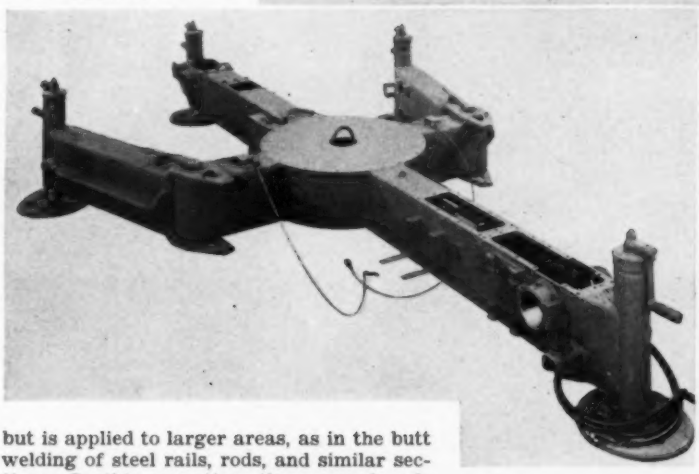
A good example of the vital role welding has played in war production is found in the American manufacture of the Swedish Bofors 40-mm. automatic antiaircraft gun. Originally its gun carriage was riveted throughout. By the substitution of welding, enormous savings in time, manufacturing costs, and materials have been effected. At above left is shown the welded front, or swivel, end of the gun chassis as compared with the riveted end, below

POPULAR SCIENCE

Because of its unusual effectiveness in defending troops against low-flying enemy planes, the Bofors gun has now been widely adopted by both British and Americans

Data and illustrations from study submitted to James F. Lincoln Arc Welding Foundation by Dr. John L. Miller of the Firestone Tire and Rubber Co.





Above, the carriage as it appeared when first imported into the U. S. to serve as a model for American builders, and at left, the carriage as it now appears, welded

but is applied to larger areas, as in the butt welding of steel rails, rods, and similar sections. In this operation, the squared ends are butted together under pressure and the current applied. "Flash welding" is an operation in which the current flows across a gap between the pieces, forming multiple arcs. As soon as melting takes place, the pieces are brought together under pressure.

A notable welding method, which is relatively new, is the atomic hydrogen arc. This form of welding has many advantages, particularly in the joining of thin metals and of those with critical melting points. In this system, the arc is drawn between two 1/16-inch tungsten electrodes and burns in an atmosphere of pure hydrogen. In practice, such an electric welding "torch" holds the two electrodes inclined toward each other, with the hydrogen jet impinging on the arc drawn between them. In such an atmosphere, the arc does not "burn" the metal to be welded, as oxygen is excluded. The two tungsten electrodes are consumed very slowly and the temperature of the arc is about 4,000 degrees C. at 30 amperes. Such an arc will weld chrome steel and many of the lighter alloys with ease, and gives great promise for airplane work.

One of the most far-reaching of the new applications of welding, which will have a radical effect on industrial methods and on the generation and transmission of steam power, is the new science of welding pipe joints for high-pressure service. Heretofore, high-pressure pipe lines have been limited by the efficiency with which pipe joints could be made leakproof. By the best methods available, through bolting, gaskets, and calking, joints could be made to withstand a pressure of 200 or 300 pounds per square inch. But now, arc-welded pipe joints can be made which will stand up under pressures of 1,500 pounds and upwards, at 1,200 or more degrees F.

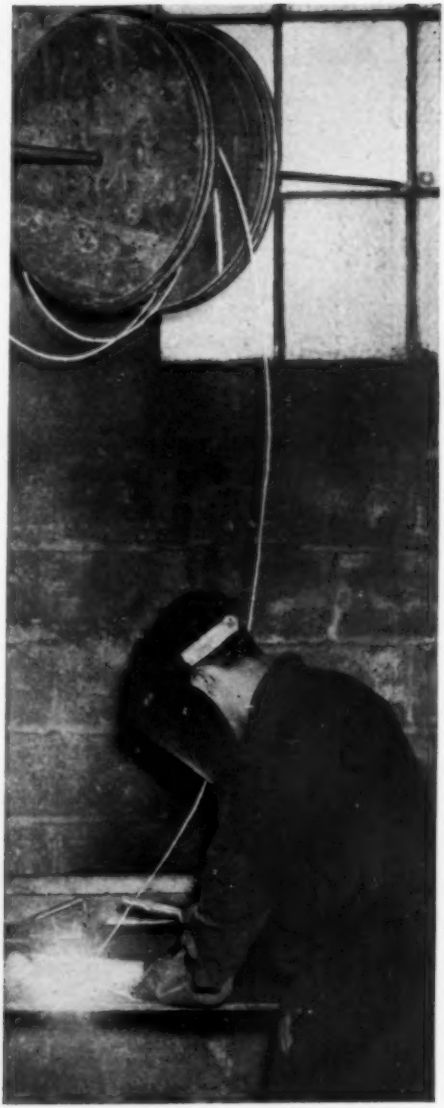
And that isn't the whole story. Obviously, such joints must be welded in place. Secondly, the molybdenum steel of which these extremely high-pressure pipes have to be made possesses a peculiar property — its strength increases as it is heated up. Under such pressures, of course, the pipe is continuously hot, and so withstands the pressures that much better. And thirdly, such pipes cannot be welded cold because at a reduced temperature the steel becomes brittle, and the heat of the weld would form microscopic cracks in the metal around the joint. To overcome the problem of welding this unusual kind of pipe, electrical engineers have devised an ingenious solution.

The pipe joint and the metal immediately

adjacent are wrapped with several turns of heavy conducting cable, through which a current of high amperage is passed. This current has an inductive effect which produces heat in the interior of the metal pipe itself and a temperature suitable for welding is thus created in a relatively short time and with a minimum of inconvenience. The weld is then made while the joint is hot, the heat thereafter being reduced by gradually decreasing the current. Thus, any possible stress effects are relieved and the high-pressure joint stays tight at the temperature at which it was intended to operate.

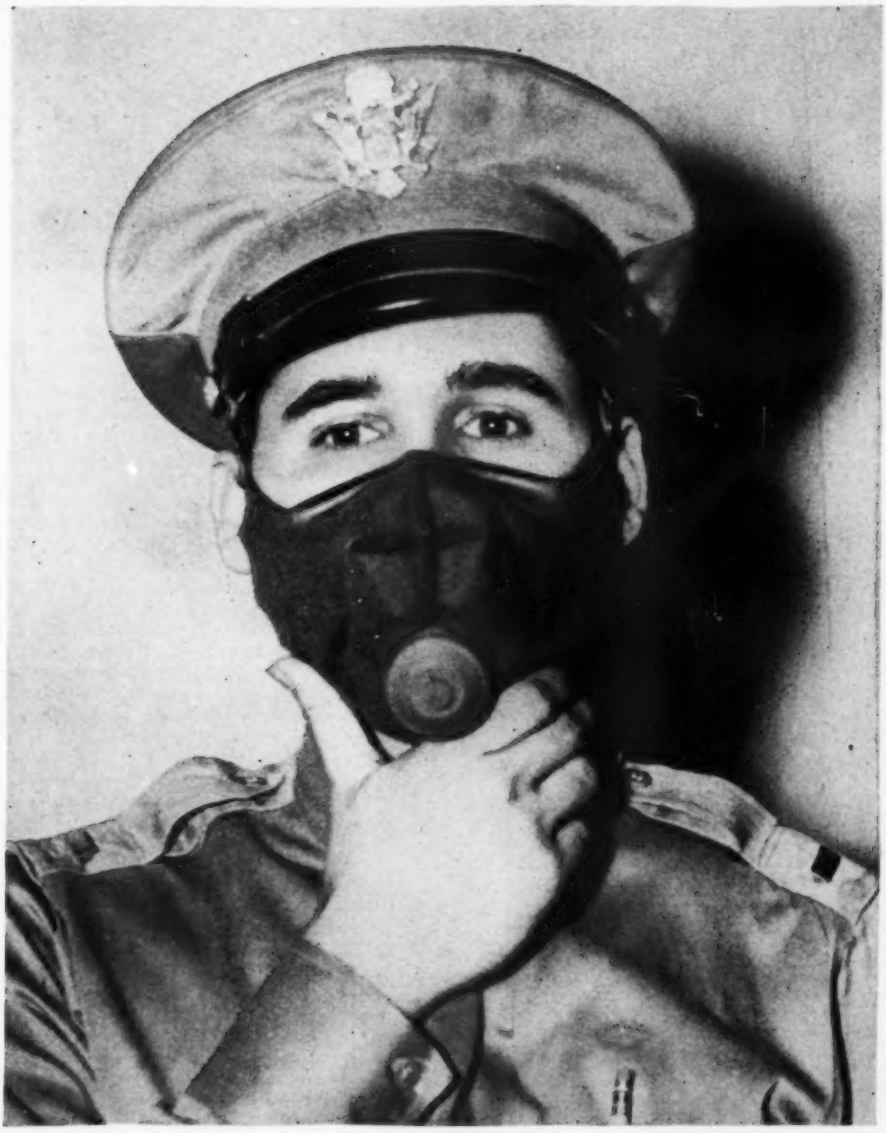
In addition to the proved speed of welding, it is estimated that an average of 18 percent less steel is required to build a welded structure than to erect it by riveting. For instance, on a freight-car underframe weighing 10,500 pounds, welded construction saved over 1,000 pounds, or enough to build one extra frame for every 10 produced.

There is now practically no structural metal that cannot be welded by some method, and welding engineers freely predict that the time will very soon be at hand when there will be no structural joints except welded ones. Already the increase in welded construction of all kinds is so great that producers of new metal alloys now find it impractical to place them on the market until their research engineers have evolved suitable welding methods for the material.



A recent innovation to speed up arc welding, as shown on page 82, consists of a continuous electrode that is fed to the operator from an overhead spool. Electric current is run through the wire itself, and as it is used up in the welding process, the operator merely slides his spring clamp higher up the wire, thus saving the time consumed in changing electrodes

At left, a mine-locomotive wheel gets a new lease on life in this electric welding machine which fills in inch-deep grooves in the tread



Dust Mask for Desert Fighters

A NEW type of respirator for soldiers operating in either dusty or smoke-filled areas has been developed by the Chemical Warfare Service, and has already been issued in quantity to our forces fighting on desert fronts. Selected after long experimentation with a wide variety of respirators, the new mask consists of a filtering felt mounted on a rubber frame, and carries both an inlet and outlet valve. Among its many advantages are that it is light and comfortable, doesn't hamper the vision, and will stand up under the hardest usage. The respirator carries no lenses as it is intended to supplement the goggles usually worn by truck drivers and motorcyclists.

(Contributed by Brig. Gen. Alden H. Waitt, author of "Gas Warfare.")

Textiles for Civilian Use Are Getting Scarcer Every Day. Here Are Some Hints That Will Help You to . . .

Save

PROPER CARE AND A STITCH IN TIME WILL ADD MONTHS OF WEAR TO GARMENTS THAT HAVE TO LAST FOR THE DURATION

Don't — leave shoes kicking around loosely, nor hang your clothes on hooks. This kind of treatment takes the life out of garments

Do — hang coats on hangers, use clamps for pants, protect unused clothes with paper covers, and keep trees in shoes

IF YOU are looking for still another way to contribute to the war effort, you'll find the answer right in your own home—in the clothes closet. Clothing materials are getting scarcer, manpower used in civilian products is more urgently needed in war production, and Uncle Sam can use every last dime of those dollars you've been saving to buy new clothes with. It all adds up to one thing: reconditioning your clothes so that they will last longer and still look as well as ever.

The best way to save clothes is to give them a little consideration. Periodic brushing and pressing, for instance, will go a long way toward increasing their length of service. When you are not wearing them, hang them up on wooden or cardboard hangers, and do it before your body heat leaves them. Be sure that you remove from the pockets all heavy or bulky objects which may pull the clothes out of shape.

Remove all stains and spots promptly. These have a way of working themselves into the material, and the longer they are left, the harder they are to take out. Also wear a different suit every day. Even if you have only two, alternate them. This gives your clothes a chance to recuperate from the strain of wearing, and will increase the life of a suit by as much as fifty percent. The same is true of shoes. Change them frequently, shine them regularly, and see to it that they occasionally get a thorough application of saddle soap. Hats, too, can be kept looking well longer by being brushed and dry cleaned period-

Your Clothes

ically, and kept on blocks when not in use.

And now for the reconditioning of those clothes you thought were ready for the secondhand man:

POCKETS. Either mend a worn or torn lining promptly, or replace it entirely. If the outside of the pocket itself is torn, reinforce it on the inside with muslin. Be sure that you sew firmly. If the ends of the pockets require strengthening, work arrowheads into the corners. On lighter materials, triangular patches can be applied to simulate arrowheads.

REINFORCING. Threadbare spots are usually found at the elbows, under the arms, and on the side where books and purses are carried. These places can be reinforced with lightweight cotton or rayon of the same color

A neat way to solve the problem of the worn collar is to remove the collar and wear the garment as a sport coat, as at above left. If buttonholes, cuffs, and pocket edges also are frayed, they and the collar can be covered with a suitable contrasting material, as at right

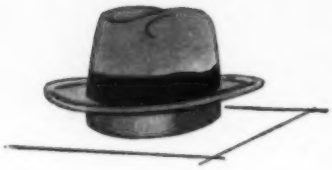
REPLACE WORN POCKET LINING
REINFORCE WITH MUSLIN STRIP
PLACE NAILS UNDER BUTTON
SEW AROUND NAILS
REMOVE NAILS AND MAKE FIRM SHANK BY WINDING WITH THREAD
RELINE LOWER PART OF SLEEVE WITH OTHER MATERIAL
PATCH WORN PLACES WITH MATERIAL TAKEN FROM LOWER PART OF SLEEVE LINING

How to make a long, sturdy shank for a button, and mend the worn lining of a sleeve or pocket, are shown at left. Repairs like these can be forestalled by changing suits every day. One-day wear gives your clothes a chance to "rest"

as the material being mended. In stitching back and forth, be sure to follow the weave. If the spot is very thin, lengthwise or crosswise ravelings of the material can be placed on the underside before the reinforcing is done. Lengthwise ravelings can be taken from the seams, crosswise ravelings from the hem.

INVISIBLE PATCHES. Following the thread of the material to be mended, cut the patch to cover the hole with at least a one-inch margin. Fringe the patch by raveling it one-half inch on all four sides, and place it on the material so that the two weave patterns match. Baste the patch, draw the raveled threads to the underside of the garment with a crochet hook, and then take the threads into the material. Lastly, stay the patch on the underside with hand-stitching. Do the job carefully, and you'll have a hard time trying to find where the hole was in the first place.

RIGHT-ANGLE TEAR. If threads of the material have been carried away in the act of tearing, place ravelings under the tear before mending. Use a very fine cotton thread, either black or a darker shade than the material, and sew the corner of the tear without puckering. Starting at the corner, stitch back and forth to each end of the tear. Finish by reinforcing the underside strongly with twilled tape.



When it isn't on your head, keep your hat on a block. If it gets wet, pull the leather band down and smooth out the crease. This prevents the oil in the band from staining the brim, and helps the crown dry to original shape

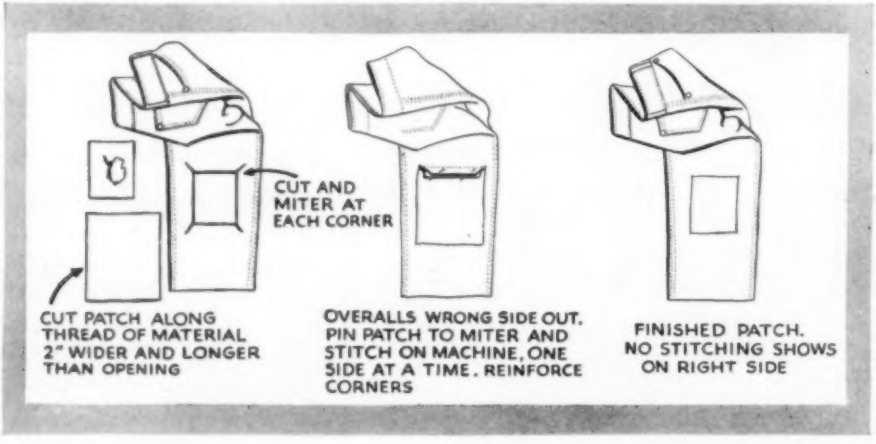
SHIRTS. If the collars or cuffs are frayed, take them off the shirt, either mend them with needle and thread or reinforce them with washable mending tape, turn them inside out, and stitch them back into place. If the collar of a white shirt is past repair, rip it off, buy a new collar—one that is guaranteed not to shrink—and sew it on.

SWEATERS. These, as you probably well know, usually wear thin at the elbows. If you can catch the job before the yarn wears through, the first thing to do is to reinforce the underside with loose stitches running lengthwise and crosswise to form a woven-in yarn network. Then on the outer side you can simulate the actual knit of the sweater with rows of chain stitching. Be sure, of course, that you use matching yarn.

If, however, a hole has already worn through, first mend it with loose, even darn, and then put ribs on the outer side in alignment with the ribs of the sweater.

The following are the materials you should have on hand to keep your clothing in good repair. No one will accuse you of hoarding if you build up an adequate supply of them. (1) Wool mending yarn, and ends of knitting yarns. (2) Scraps from altered trousers. (3) Overall patches. (4) Ready-made pockets, or a half yard of drilling.

To put a firm, neat-looking patch on your overalls, cut a square around the hole, and then make a small diagonal cut at each corner of the square. Turn the trouser leg inside out, and fold back the four flap edges made by the diagonal cuts. Put the patch on the flaps, and then baste and stitch as shown

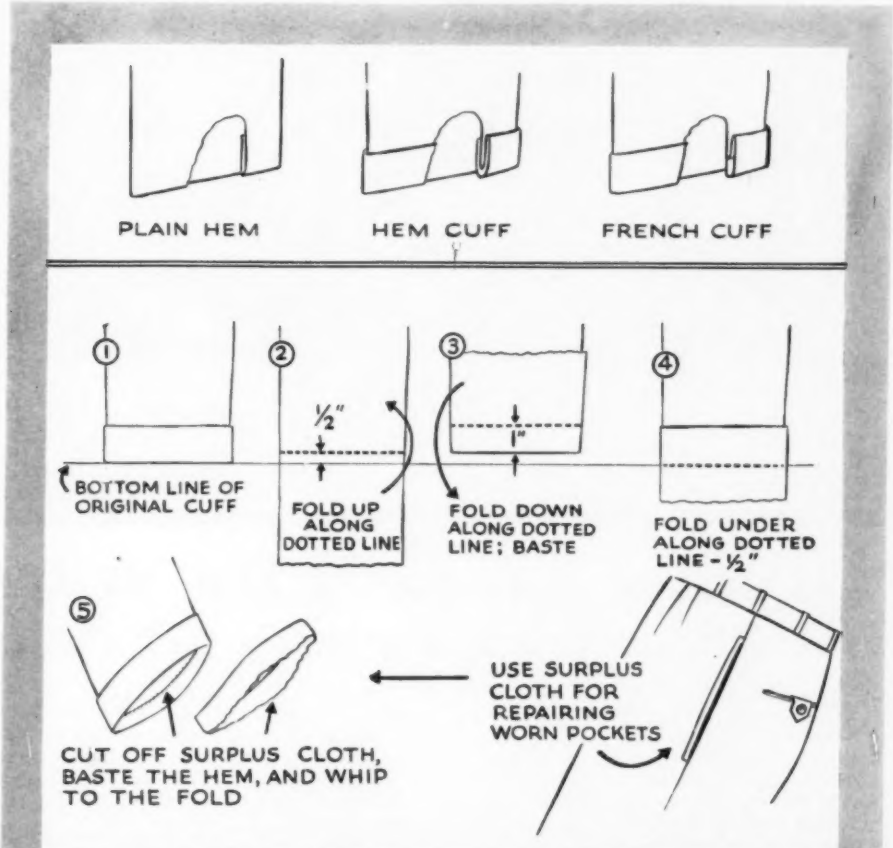

CUT AND MITER AT EACH CORNER
CUT PATCH ALONG THREAD OF MATERIAL 2" WIDER AND LONGER THAN OPENING
OVERALLS WRONG SIDE OUT. PIN PATCH TO MITER AND STITCH ON MACHINE, ONE SIDE AT A TIME. REINFORCE CORNERS
FINISHED PATCH. NO STITCHING SHOWS ON RIGHT SIDE

(5) Buttons, including bachelor buttons. (6) Twilled tape; black, white, brown, and gray. (7) Black thread, Nos. 80 to 100, and No. 30. (8) Mending tape that can be applied with a hot iron, and guaranteed to wash and dry-clean.

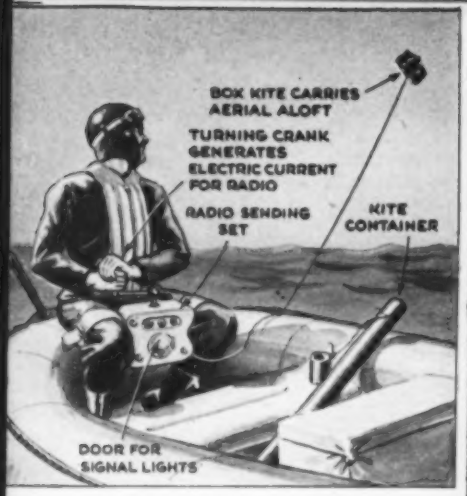
Proper storing of clothes is every bit as important as prompt mending and careful handling. In the case of woolens, the big hazard, of course, is moths. The best way to cheat them is to have each article dry-cleaned and then store it after the solvent has evaporated, but before it has become deodorized. The odor will help to repel moths. The articles should then be wrapped in paper and placed in covered boxes. If after diligent inspection you're sure your clothes don't need to be dry-cleaned, then at least give them a thorough brushing, being sure that you clean well along the seams. When the time comes to wear the stored clothes again, air them thoroughly in the sun and then press them.

In storing cottons and linens, first wash out all starch or they will fall victim to mildew, crickets, or termites. After washing, dry the material with a prolonged sunning. As for rayon, which crickets and termites particularly enjoy, either launder or dry-clean the material, and, after folding, insert tissue paper between the folds.

The attic, the cellar, or the garage is a good storage place for clothes—provided it is dry.—ANDREW R. BOONE.



At the top are three types of cuffs that may be worn with trousers. (Wartime conservation curtailment of clothing material does not apply to old clothes.) Raising the hem ¼ inch solves the problem of the frayed plain hem, and making a French cuff, as illustrated, does the same service for the frayed hem cuff. All left-over material should be saved for future mendings


BOX KITE CARRIES AERIAL ALOFT
TURNING CRANK GENERATES ELECTRIC CURRENT FOR RADIO
RADIO SENDING SET
KITE CONTAINER
DOOR FOR SIGNAL LIGHTS

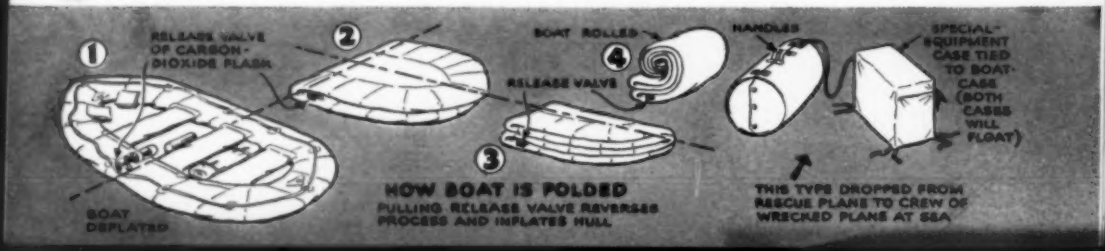
Radio sending set includes kite for aerial—hydrogen balloon for use when the wind fails

TARPAULIN COVERS HULL AND 7-MAN CREW IN BAD WEATHER. BLUE SIDE IS FOR CAMOUFLAGE, YELLOW FOR VISIBILITY
YELLOW
RELEASE VALVE OF CARBON-DIOXIDE FLASK
PLASTIC HAND PUMP
SEATS ARE INFLATED BY PLASTIC HAND PUMP
HULL IS INFLATED WITH CARBON DIOXIDE. IT IS DIVIDED BY A HORIZONTAL BULKHEAD INTO AN UPPER AND LOWER COMPARTMENT
STEERING OAR
YELLOW
CARRYING CASE SERVES AS SEA ANCHOR IN ROUGH SEAS
WATERPROOF CONTAINER FOR FOOD AND WATER. ALSO HOLDS RADIO, SIGNAL, EMERGENCY REPAIR, AND FIRST-AID KITS. IT IS TIED AT FOUR CORNERS TO HEAVY CANVAS FLOOR
VALVES FOR PLASTIC HAND PUMP
10 LENGTH OF ROPE ON EACH SIDE FOR RIGHTING OVER-TURNED BOAT

"Luxury Liner" Life Raft for Bomber Crews at Sea

Drawings by STEWART ROUSE

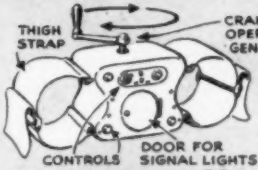
NEW comfort and protection for flyers forced down at sea are provided in an improved rubberized-fabric life raft designed by the Equipment Laboratory of the A.A.F. Materiel Center, Wright Field, Ohio, in collaboration with the United States Rubber Company. Based on experiences of Army flyers, improvements make the boat roomier and more seaworthy, and include many features to reduce the hardships of the men and give them a better chance of survival



OARS SERVE AS YARD AND MAST FOR 6'-6' SAIL
YELLOW
BOAT PAINTED BLUE BELOW WATER LINE TO AVOID ATTRACTING SHARKS
ZIPPER-TOP CASES HOLD KNIFE, REPAIR KIT, WHISTLE, BULLET-HOLE PLUGS, AND SMALL ARTICLES

Roomier design accommodates seven men in comparative comfort. Boat repair kit has plugs for stopping holes made by bullets

CONTENTS OF SPECIAL-EQUIPMENT CASE



SET SENDS SUSTAINED SOS OR MESSAGES OVER 400 MILES

RADIO

BANDAGES, SWABS, ANTISEPTICS, SUTURES, ETC.

FIRST AID KIT

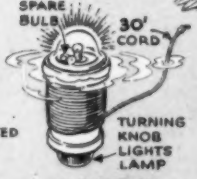
PATCHING MATERIAL, RUBBER CEMENT, GROMMETS, NEEDLES, THREAD, SCISSORS, ETC.

BOAT REPAIR KIT

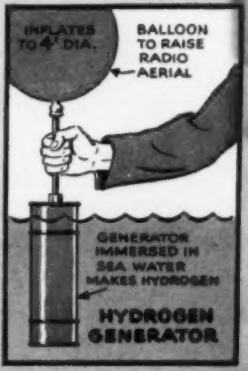
FISHING KIT

ARMY "K" CONCENTRATED FIELD RATIONS FEED 7 MEN FOR 3 DAYS, 10 DAYS IN A PINCH

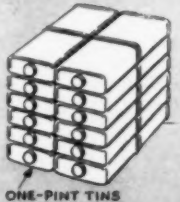
FOOD



FLOATING FLASHLIGHT

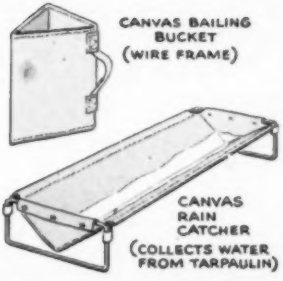


HYDROGEN GENERATOR



WATER

SIGNAL KIT



THIS TYPE IS LAUNCHED FROM PLANE DOWN AT SEA

SELECTION, TRAINING, INTEGRATION —THREE REASONS WHY WE HAVE THE

PT-17 Many of our pilots learn the ABC's of flying in this Boeing primary trainer. Its 225-hp. Jacobs engine gives it a top speed of 125 m.p.h. Many primary trainers retain the biplane rig, well suited to elementary flying

By WILLIAM S. FRIEDMAN

"OUR FLYERS are the best in the world!"

So says General H. H. Arnold, commander of the U. S. Army Air Forces. Flat statements from Arnold are rare. He is as cautious in speech as he is daring in tactics. He made the statement to a graduating class at Randolph Field a year and six days after Pearl Harbor. The commander had adequate time to draw a real conclusion.

Then he quoted the score to prove it. From February 1 to December 5, 1942, the Army Air Forces had destroyed 928 enemy aircraft, losing but 234 of their own; an all-over advantage of nearly four to one.

Consider the fact that most of our airmen lacked previous combat experience, and faced air organizations seasoned by three to five years of actual warfare.

What is it then, that our flyers have that qualifies them to remain alive in the face of this superior experience, and to roll up overwhelming evidence of personal superiority?

Some theorists claim that the average American is physically and psychologically superior to the typical Axis warrior. Our practical militarists prefer to let Herr Goebbels carry the propaganda ball for the super race, while we build a super air force from plain average-run Yanks.

Leaving the Superman theory to Axis prevaricators and comic-book artists, it is possible to trace the military margin to more prosaic reasons; selection, training, and integration.

Our pilots have more flying time before they get a look at the enemy than most Axis airmen have before they are finally shoveled under. The typical Yankee combat pilot has 200 flying hours in primary, basic, and advanced training; 100 more in transitional schools; 200 in operational schools; and a final polishing off right behind the theater of combat to fit him into the local military conditions. In the 1918 scrap, pilots were sent into battle with about 90 hours, to face veterans of three years' combat. The Germans knocked them down with both hands. This trip it is different.

Typical of the reports on the results of our training is one that came back with the 19th Bombardment Group, home from Australia. For several anxious months, 48 Flying Fortresses had held the balance between success and failure in Japan's attempt to invade the down-under continent. Now that proper reinforcements have been

World's Best Flyers

sent there, and the war-tired veterans brought home to spread their experience among the younger airmen, it is safe to tell how thin that red line was between ourselves and defeat. While it would be unjust to state that these 48 crews, unaided, held off attack, their constant pounding of Rabaul and other points probably set the Japs off balance so that a full-scale jump onto the continent was impossible.

The total score of these craft that operated unaided by fighters may be remembered as long as airmen fight in the sky. Most Americans reading in dispatches from Australia before last November that General MacArthur's Fortresses had again raided Jap installations in New Guinea, pictured swarms of four-engined Boeing B-17's leaping out of carefully constructed, miraculously camouflaged runways, to pound Rabaul again and again.

It wasn't that way. MacArthur's Fortresses were for many months a mere four dozen, many of them patched from wrecks dragged out of the Philippines. They were kept in the air with Yankee ingenuity, defended on the ground with plain guts, and kept potentially dangerous by the best training and teamwork ever known to mankind. They were attacked with the best fighter equipment the Mikado could conjure up. Still the Fortresses remained as the outer rampart of the continent. Now, amply reinforced, Australia appears impregnable.

The evidence piles up that General Arnold is right. As the final scores are tabulated the total indicates that the four-to-one advantage is holding and growing greater. The margin of superiority holds and holds well. Why?

We, as a nation, are willing to spend the money for adequate training. While time is carefully doled out and every tick of the cadet's clock put to work, we have skimped no material and effort to give our airmen the best possible chance of survival and victory. Our selection for air training is made strictly on merit and performance. Compare this with the German system where the first requisite for nomination to the Luftwaffe is race and political connection. In Nippon, selection is made by family.

Like the aircraft they fly, our airmen's superiority comes first from the selection of proper materials. Making silk purses from sow's ears and pilots from ninnies or ham-fisted thickskulls is equally disappointing work. The Air Force's first job is to get men who are first-rate timber.

The cadet selection board takes the first step in the necessary weeding out. The basic primary physical requirements are well known. A good airman must have the stamina to stand up to the physical wallop that aviation gives the human frame. The innovation is in the psychological factors involved: is the man men- [*CONTINUED*]

PHYSICAL TRAINING includes exercises designed to give a pilot the "swivel neck" he requires in order to be on the alert for enemy planes approaching from the side or behind, without turning his body away from the controls of the plane

PRIMARY TRAINERS

PT-19 This low-wing Fairchild monoplane is typical of our primary trainers. Powered by a 175-hp. Ranger engine, it is a well-behaved ship, but is by no means "foolproofed" against careless handling

PT-25 Built of resin-bonded plywood, the new Ryan trainer uses practically no strategic materials. A 165-hp. Lycoming engine drives it. Night-flying equipment is included

PT-22 Another Ryan ship, the all-metal PT-22 is one of the lightest in use. A similar plane is used by the Navy as the NR-1. Ryan was a pioneer in low-wing primaries. Kinner engine, 160 hp.

ARMY FLIERS LEARN THEIR JOB IN THESE PLANES

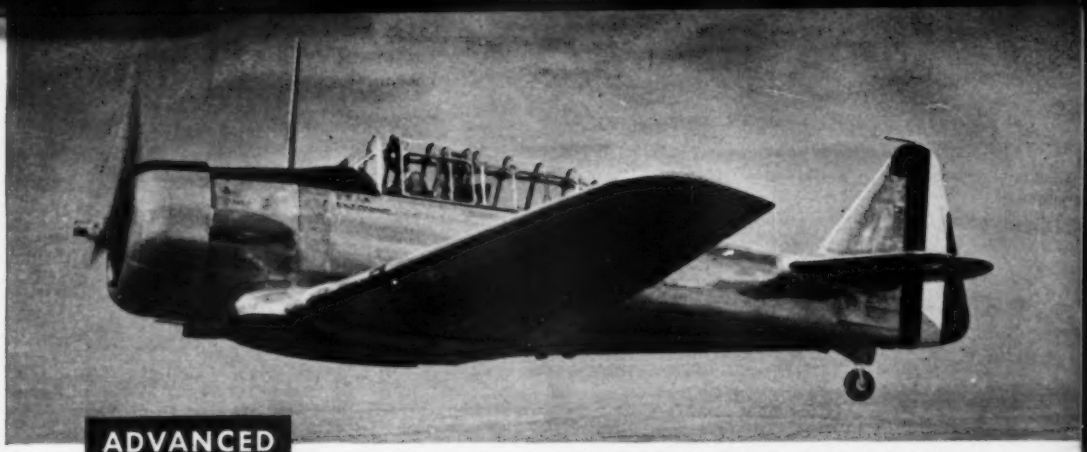
AMERICA'S pilot-training philosophy is nowhere better exemplified than in the high quality of our training planes. Beginning with primary trainers, which have power plants ranging from 165 to 265 horsepower—against 85 to 135 in the primaries of other principal air powers—all the way through the list we spare no expense to give our airmen the training that will fit them both for survival and for eventual victory.

BASIC TRAINERS

BT-9 Like all other basic trainers, this North American is a low-wing job. At this stage, the cadet tackles cross-country and formation work

BT-13 For basic training, the cadet steps into a job like the Vultee seen below. A P.&W. Wasp engine jumps horsepower up to 450

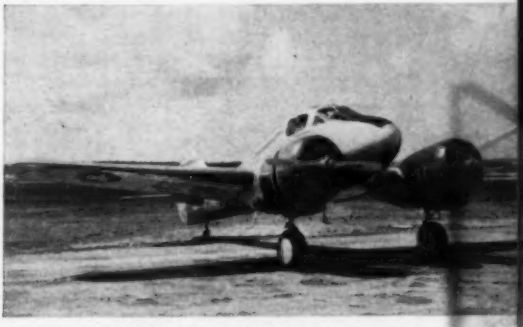
BT-14 Another North American, the BT-14 has a fuselage of welded steel tubes and metal covering. Wright Whirlwind, 420 hp.



ADVANCED TRAINERS

AT-6 In an advanced trainer such as this North American, the cadet first encounters the characteristics of a modern military airplane. It has a 600-hp. engine as well as all the various qualities that go with it

AT-8 This Cessna is a twin-engine job. Advanced trainers are equipped with guns, retractable landing gear, high-compression engines, navigation instruments, radio installations



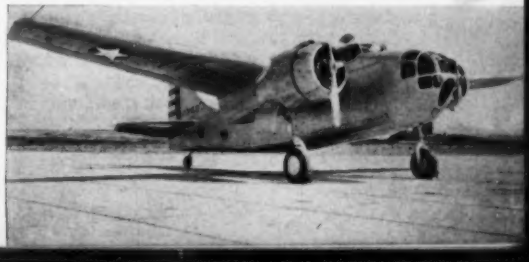
AT-9 Curtiss, twin-engine. In advanced training, cadets begin simulated combat work, cross-country night flying, fixed-gun shooting, tight-formation flying, landing on small fields

AT-11 Bombardiers polish up their aim in this Beechcraft, learning to use the secret bombsight with the accuracy that amazes the world

AT-10 Like the AT-8 and AT-9, this Beechcraft give fledgling pilots the feel of the twin-engine fighter and its flying qualities

AT-14 Bomber crews practice teamwork in the Fairchild plane below. Built of plywood, fitted out like a bomber, it carries dummy bombs

AT-15 Another crew trainer, a Boeing ship. Has bomb racks, power-operated gun turret, full radio and navigational equipment



tally equipped to fly? If so, what kind of flying will he be good at? Does he belong in the cockpit at all, or at the navigator's table or lying flat on his stomach operating our precious bombsight?

The young American, below the age of 27, in good health and possessing at least a high-school education or better, applies to his local cadet selection board with three letters of recommendation from persons of standing in his community. He undergoes a physical examination similar to that given any officer candidate. Subsequent tests tell more about his personal qualities and qualifications than any number of diplomas or letters of recommendation, however detailed. They show exactly where he stands in the things that the Army needs in its flyers. The most important fact which the primary psychological search tries to determine is whether the cadet candidate is mentally equipped to learn—whether he can absorb the complex information about to be flung at him completely, accurately, and in the short time which the war emergency provides for him.

This qualifying exam has proved so accurate that the two-year college requirement, previously held as absolutely necessary, has now been virtually abandoned. Actual military experience indicates that, in many cases, a purely academic attitude may kill the very instinct that makes an audacious pilot, an imperturbable bombardier, or a nerveless navigator.

The primary examination has been rigged by the psychologists to determine whether the candidate has the basic stuff of which Air Force personnel is to be formed. Can he comprehend instructions? Can he size up new and unfamiliar materials and situations? Can he follow directions accurately without lengthy auxiliary explanations? His judgment must be dependable, his sense of organization flawless. The qualifying exam weeds out most of the unfits, but the dangerous job of weeding out the border-line cases comes farther along the line.

Once appointed, the men are moved along to the reception centers, where they are sorted out to determine just what job they will hold later on. Commissioned air-crew members are divided into three classes of activity; bombardiers, pilots, and navigators. There was a time when men who were unable to make the grade as pilots were trained to hold the other two posts. Psychologically, this was a poor system, a relic of World War I. In spite of itself, it produced some excellent air-crew members, simply because the basic requirements for navigator and bombardier differed so vastly from that of the pilot that there was a good chance that if the man flunked out in his flight checks, he had what it took for one of the other two air posts.

The bombardier requires excellent hand-eye co-ordination, superior finger dexterity, great motor steadiness, and the ability to make complex calculations under conditions of the utmost stress. In addition to this, he must have sufficient mechanical aptitude to operate the complicated bombsight.

A pilot, on the other hand, must be able to absorb the complex motor skills involved in flying, the physical business of getting one's hands and feet together and in perfect rhythmic movement, to go through the complex motions required in flying the modern airplane. He must demonstrate superior reaction time and an ability to make quick, accurate observations, and possess a certain cockyness required for combat. The fighter pilot should, in addition, possess a certain "killer instinct" that makes him different from other pilots or air-crew members.

The navigator, on the other hand, must be the imperturbable pedant of the crew. Besides the prerequisite flair for mathematics, he must possess not only the motor co-ordination required for the handling of navigation instruments, but also a calmness that permits him to continue his calculations despite setbacks and interruptions.

A battery of tests awaits the cadet when he arrives at one of the reception centers. His case history, his childhood, and his education are carefully checked into. Another written examination follows, but the burden of the physio-psychological determination of what he is good for is borne by apparatus tests which determine which of the three jobs, if any, he is good for. The apparatus is purposely deceiving, so that no ambitious kid fitted for the navigator's post may deliberately flunk his way into flying school.

There are no hard-and-fast rules about selection. The psychologists are working on new examinations all the time, and when new tests are rigged and found to be more accurate, they are placed in the examinations, supplementing or replacing those in use. For instance, there is the simple peg-turning test. Students are placed at a board in which are set rows of pegs. Half the peg tops are painted black, the other half white. The student is instructed to turn each one 180 degrees. The time and accuracy are clocked and recorded. A similar test of moving pegs from one board to another a full arm's length away, checks arm and hand dexterity.

Discrimination reaction time is tested by red and green lights placed on a board in front of a seated student. Certain combinations are extinguished by switches at the

student's hand. When the cadet gets the right switch to match the combination, a white signal light goes out. The factor recorded is the amount of time it takes the cadet to extinguish the white light in 50 tries.

Serial reaction time is another characteristic which the psychological lab tests with great interest. Its rig seats the cadet at a set of dummy airplane controls, stick and rudder, in front of a board on which a set of light buttons describe the three-dimensional motions of a plane in flight. The lights are set in two rows, one red and one green. The lines of lights describe a curve across the top for bank or side-to-side motion of the stick, up and down for the stick's forward and back movement which represents nose up or down in the plane. A straight horizontal set records the movements with the rudder bar. With a complicated set of electrical switches, the examiner flashes a control position, indicating it with one set of lights. The student must then bring the controls into such a position as to light the set of buttons opposite those already lit. The reaction time and accuracy is tested.

"YOU'LL NEVER BE A PILOT!" yells the heckling sergeant, just by way of being helpful as a cadet is taking a test for steadiness of hand. Amid such distractions, he must hold a metal stylus steady in a hole in the box. If his hand shakes, an electrical contact is made and he gets a black mark

Most cadets think this test is exclusively for testing prospective pilot ability. Actually no one test determines a final selection. This piece of apparatus merely indicates how well a cadet can get his hands and feet to act in unison to produce a desired effect under pressure. Many a budding pilot has been "thrown" by this hurdle, fearing lest this was the final test whether he was to fly, navigate, or bomb.

Steady hands are a prerequisite in all three posts in a bomber. The pilot must be able to fly a straight course to an objective through a hail of antiaircraft fire in the final bomb run. The bombardier must lie and manipulate his sight while the rest of the crew mans machine guns to ward off the attack; the navigator must hold the sextant in untrembling hands when all his precalculated courses are shot to the devil by adverse weather or military conditions.

The cadet is seated at a tiny box in whose cover is a nail hole. He is handed a charged metal stylus and told to insert it in the hole and hold it steady, without touching the sides. If a contact is made, the circuit is closed and a point is recorded against the student. Forewarning the student as to what is going to happen has little or no effect on the result. He sits down, determined to hold steady, come what may. Then a noncommissioned officer sneaks up behind him murmuring such words of encouragement as, "So you think you'll be able to fly, flutterfingers—why, you cluck, there are better heads than yours on cabbages. If you can't hold still now, what'll you do when the ack-ack starts shooting?" Then a bunch of scrap-metal hung from the ceiling in the opposite room is dropped with a sound like the crack of doom, or a klaxon is sounded close to the cadet's ear. No one is perfect on this test, but a low-failure score on this test is a good indication.

Bimanual co-ordination, the art of getting each hand to work at a separate job to achieve a single unified result, is gauged by another test. If you don't think this requires skill, try this simple test on yourself: place your left hand on top of your head, your right on your stomach. Rub your head with a circular motion, your stomach crosswise. Then try speeding up the circular motion on the head and reversing direction without breaking either the rhythm or direction of the right hand. This kind of co-ordination is essential in many of the air-crew jobs. The newest piece of equipment to test this is the lathe-type tester. It consists of a flat, rotating disk like a phonograph turntable, over which rides a sliding arm with a dual-direction stylus. The movements of this stylus are controlled by two wheels, similar to those on a lathe. There is a spot on the disk, whose motion, direction, and rate of travel are highly erratic. The cadet is supposed

to keep the stylus in contact with the spot by means of two wheels. The examiners record the number of times the cadet loses contact with the spot.

New tests are introduced continually, not only because the psychological division is extremely progressive, but also because frequent discussion of the tests between students may rob them of their effectiveness. Certain tests must be a surprise to be effective; others remain standard for a long time.

At the reception centers, the students are given a chance to register their preferences in assignments. In the beginning, there was a mass rush toward the pilot appointment, but a well-organized cadet-relations program has convinced many students that the man who flies the plane is just the aerial hack driver, and increasing numbers bid for navigator or bombardier as first choice.

Wherever possible, the student is given his choice of assignments. In border-line cases, his preference is the deciding factor. Nevertheless, if he shows marked tendencies toward navigation, has the necessary education, and has the systematic mathematical mind required for such a job, he is counseled to accept this appointment.

Once the selection is made, the cadets are sent to Army preflight schools for nine weeks of Army education. Pilot candidates then move off to established Army primary flying schools to absorb the rudiments of flying.

Here the cadet makes the acquaintance of the PT series, a rugged group of primary trainers designed to give the pilot his aeronautical ABC's. He learns to taxi, take off, fly straight, climb, turn, glide, and land. He learns to land with and without power, upwind and crosswind. He learns to spiral and side slip; to stall the plane, power-off and power-on; to spin and recover. During this procedure, acrobatics are stressed, along with steep turns and chandelles.

The thing that makes our elementary flight training unique is the type of equipment we use, from the very beginning. The line of U. S. primary trainers includes the Stearman, Fairchild, Ryan, and others. The lowest powered of these ships carries 165 hp. The average is 210; some even run 265. Italy's average primary trainer is powered by a 100-hp. engine, Germany's average runs 90, and Britain's is in the 135 bracket, while Japan's primary trainers are reported to carry somewhere in the neighborhood of 85.

American instruction is based on coordination and judgment. It is built on the idea that the military pilot is destined to fly airplanes with power enough to get him into trouble if he fails to respect it—and to get him out if he handles it right.

The popular Fairchild PT-19, a low-wing monoplane powered by a 175-hp., six-in-line Ranger engine, is typical of the Army's trainers. A well-behaved airplane, it responds obediently to controls, exhibits no control trickiness or flying vices of any kind. On the other hand, no advanced aerodynamics have been built into the airplane to compensate for students' sloppiness in flight technique. The Fairchild is built with a sturdy, welded, steel-tube fuselage. Its wings are of resin-bonded spruce, fabric-covered. Unlike most primary trainers, the PT-19 is equipped with a flap or air brake; not that its landing speed requires it, but because some instructors think that its use should be made part of the flying routine early in the cadet's career.

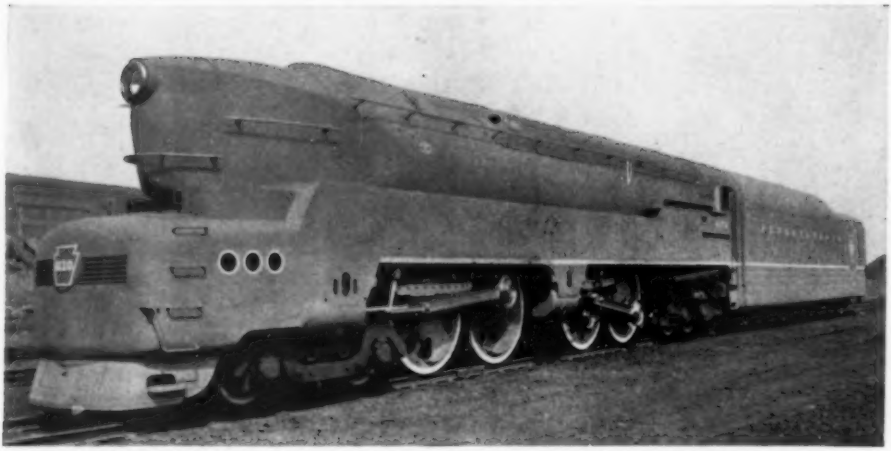
The newest of the trainer series, the Ryan PT-25, a ship built entirely of resin-bonded plywood, also has a flap. Many of the primaries, however, still retain the old-fashioned biplane rig. Orthodox builders find it easier to incorporate the basic requirements for this ship—stamina—into the two-wing design. These types include the PT-15, the St. Louis trainer, powered by a 225-hp. Wright Whirlwind; Stearman's PT-13, powered by a 225 Lycoming radial; 17 and 18, which are identical except for their power plants—the 220-hp. Continental and the 225 Jacobs. The Waco PT-14, powered usually with a 220 Continental is also in wide use. The lightest in the series are the Myers, a small biplane powered by a 145 Warner engine, and the Ryan PT-22, powered by a 160-hp. Kinner engine. Both of these ships are of all-metal construction.

The next jump is into basic training airplanes. All of these are low-wing monoplanes. The power is suddenly doubled. Sensitive flaps, landing flaps, and a controllable-pitch propeller add considerably to the pilot's woes. Most of these ships are all metal, weigh over two tons fully loaded, and are equipped with a panel full of instruments and two-way radio. Here the cadet learns instrument flying, cross-country flying, and primary formation flying. Here he puts into practice the ground-school education—navigation, meteorology, code and voice communications—that have been pounded into his cranium between flights.

The most commonly used equipment in this class is the North American BT-14, powered by a 420-hp. Wright Whirlwind engine. This ship has a remarkably tough structure. Like the average primary, its fuselage is built of welded steel tubes, but the outer surfaces are fabric-covered aluminum sections *(Continued on page 210)*

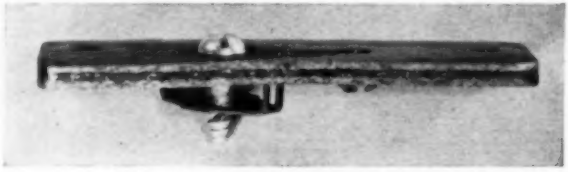
U. S. Force in Africa Elaborately Equipped

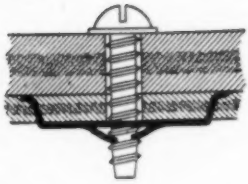
THAT American troops are the best equipped in the world is borne out by what each soldier is carrying in the invasion of North Africa. As indicated by the artist's conception, this equipment comprises everything from a tommy gun to a mosquito repellent. One thing our troops did not land with was any regimental marking that would have aided the enemy to estimate the number of men that had been landed.



STREAMLINED STEAM LOCOMOTIVES of the T1 class have been placed in passenger service on the 713-mile Chicago-Harrisburg run of the Pennsylvania Railroad. Built by the Baldwin Locomotive Works, each of the two engines being used is capable of pulling an 880-ton load at a speed of 100 miles an hour. Equipped to carry 19,500 gallons of water and 41 tons of coal, the locomotive has to make only one stop in the run. Novel feature of the engine, styled by industrial designer Raymond Loewy, is its nautical prow.

SPEED NUTS for use in plywood construction have been designed so that they can be quickly driven into position with a hammer instead of being screwed on with a wrench. When driven over the threads of the screw, the thread-gripping clips of the nut snap tightly into place, while the four pointed legs, spreading outward as they sink into the wood, achieve a spring-tension grip. If the nut is used on thin, plate-backed plywood, the leg tips merely curl up to give more gripping power.





GLASS BOLTS and nuts are being enthusiastically adopted by our war plants. Originally these highly tempered parts were valued chiefly for their resistance to acids. But their surprising strength and durability, and the saving they afford in more critical materials, have made them valuable in an increasing variety of uses. The bolts shown are about 4½ inches long, ¾ of an inch in diameter, and almost as light as a cast aluminum bolt of the same size. Nuts and bolts are being made in many sizes.

Sound Waves Help Score Bomb Hits

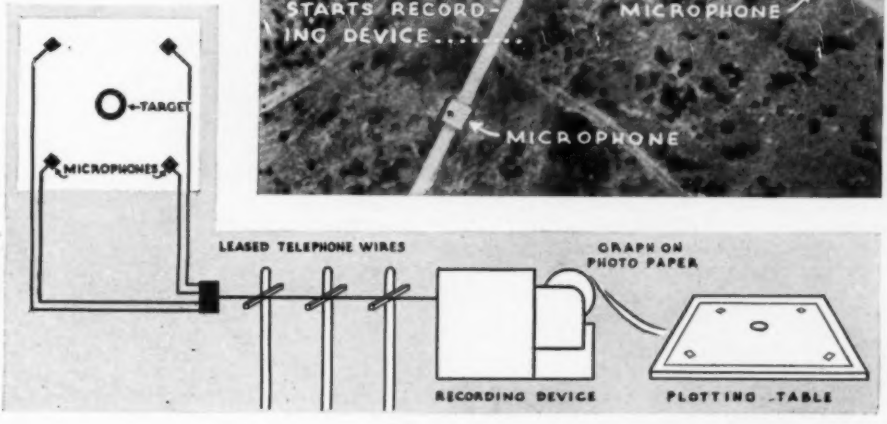
OFFICERS at the world's largest bombardier college, the Army Air Forces Bombardier School at Midland, Tex., can instantaneously check the accuracy of bombs dropped by cadets on targets 20 to 60 miles away, by means of a scoring method developed by Capt. Edward Peter McKaba. The new system, as explained in the illustrations, replaces the former scoring method in which aerial photographs were made from the bombing plane. Besides saving time, photographic film, and labor, Captain McKabe's system eliminates frequent motor trips to the target area.

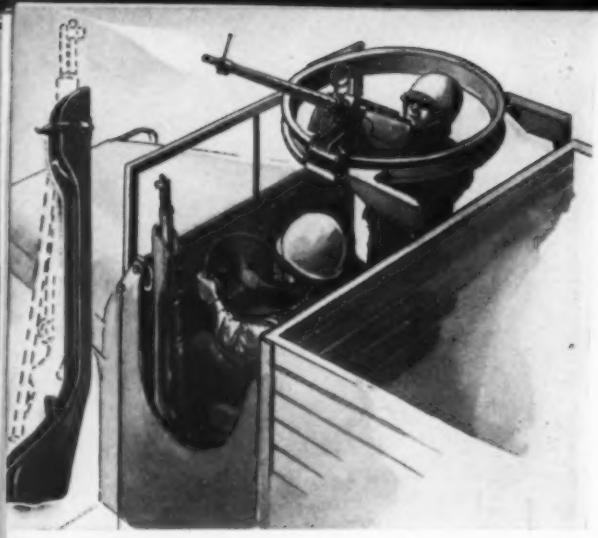
Four microphones like the one shown in the close-up at left are placed in a square pattern around the target, each 500 feet from the center, to pick up the waves created by explosions of bombs from planes

Sound waves from a direct hit will reach all microphones simultaneously. An off-center hit affects the four mikes at various times depending on nearness

By wiring the microphones to the home base, relative time values can be applied at once to a hyperbolic plotting board which shows exact position of the hit

SOUND OF OFF-CENTER HIT WILL REACH NEAREST MICROPHONE FIRST — OTHERS IN ORDER OF THEIR DISTANCE FROM BOMB HIT
MICROPHONE
MICRO-PHONE
TARGET
BOMB IMPACT STARTS RECORDING DEVICE.....
MICROPHONE
MICROPHONE

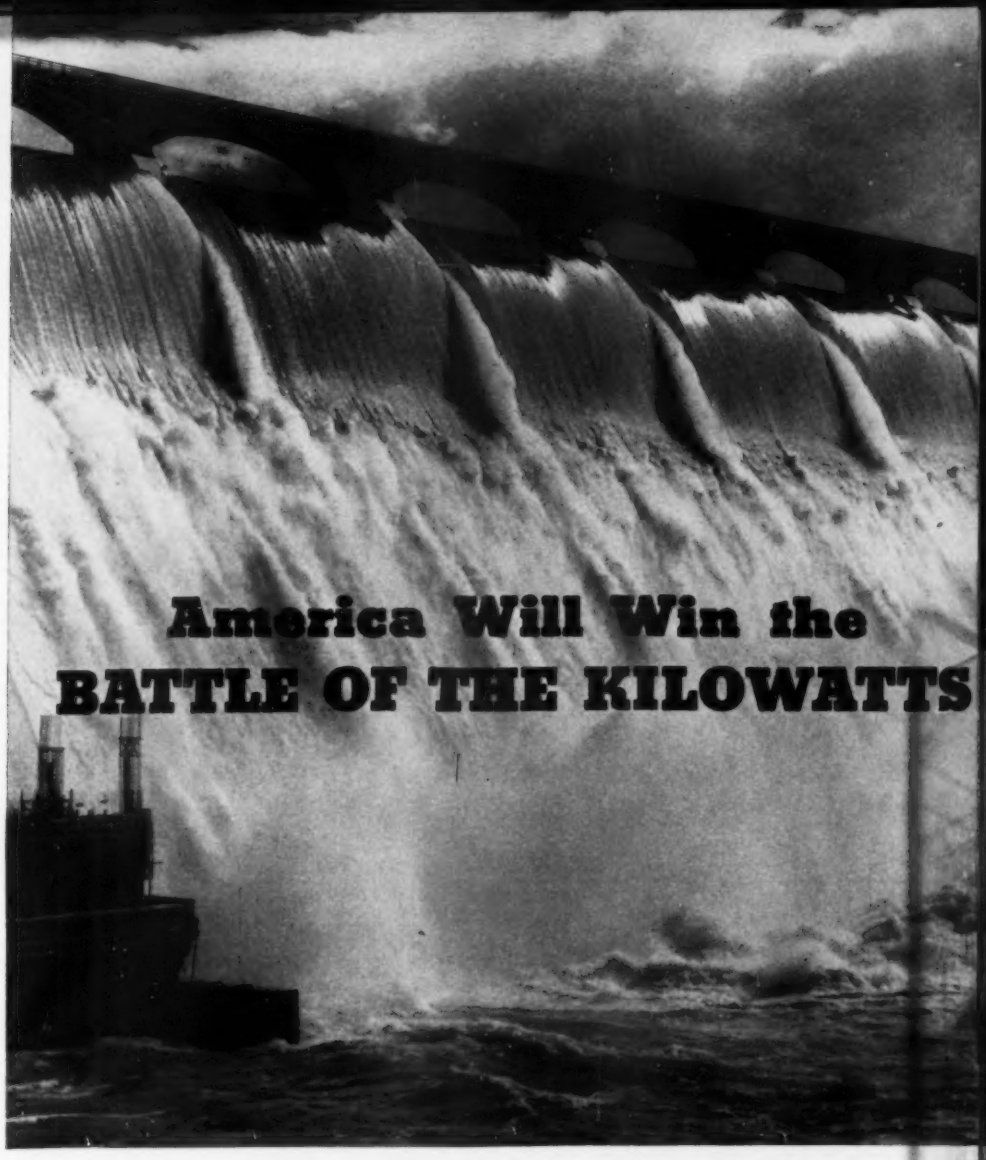




MACHINE-GUN MOUNTS for Army trucks provide effective defense against both air and ground attack. As shown in the artist's conception at left, the mount consists of a metal ring on which a .30 or .50 caliber machine gun can be turned to fire in any direction. To fire at enemy aircraft, the gunner stands on the floor of the truck. If attacked by ground forces, he folds the back of the seat forward to form a platform which raises his shoulders inside the ring. Another innovation in truck armament is a metal rack which replaces the old leather boot for holding a rifle or carbine in easy reach of the driver's hand.

CARBON DIOXIDE fire-fighting systems are now being installed on oil tankers and on gas-powered auxiliary vessels used by the Army and Navy. Carried in liquid form in steel cylinders, the carbon dioxide is kept under a pressure of 850 pounds per square inch. When released, it expands to 450 times its stored volume and quickly floods the area it has been designed to protect. The average flammable liquid requires a 21-percent concentration of oxygen to continue burning. When this is reduced to 14 or 15 percent by the presence of carbon dioxide, the fire goes out quickly. Nozzles are placed where fire may occur, and are controlled by distant valves.

TRAILERS STEERED FROM THE REAR like hook-and-ladder fire trucks are solving the problem of transporting large military gliders from the factory to points of delivery. A signal system insures teamwork between the driver of the towing vehicle and the "tiller man" who steers the rear wheels of the trailer. Gliders are safely hauled over crooked roads, across bridges, and through cities at speeds up to 40 m.p.h.



America Will Win the BATTLE OF THE KILOWATTS

Our Gigantic System of Dams and Powerhouses Pumps the Lifeblood into Vital War Industries

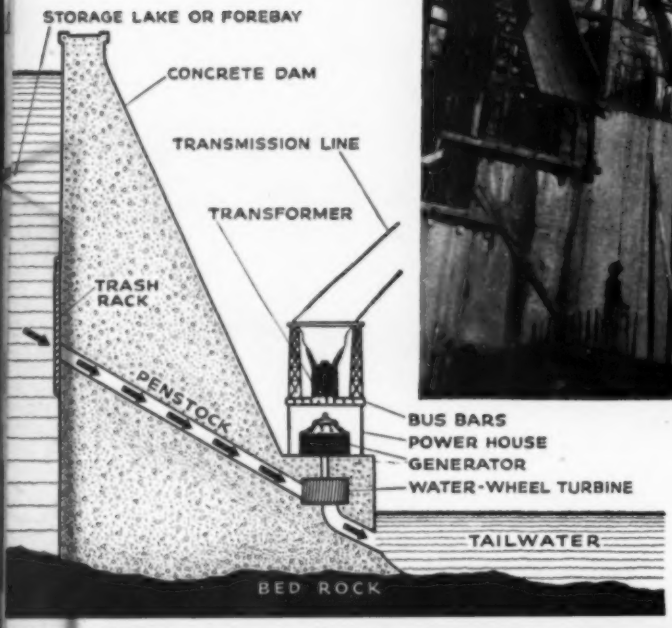
By ARTHUR GRAHAME

ELECTRICITY is the lifeblood of modern war production. We must have it in vast quantities to produce aluminum for airplanes and magnesium for bombs; to heat-treat steel for gun barrels, ships' plates, and tank armor; for the production of chlorine and other chemicals. We must have it to run the hundreds of thousands of machine tools which are turning raw metals into finished weapons. Just as important, we must have it to keep working the everyday services on which depends the sustained drive of our war effort—to run streetcars and elevators; to keep radio stations on the air and telephone and telegraph systems in operation to light factories, mines, and streets.

In the crowded, vulnerable industrial areas of Germany, power-generating stations are among the most carefully guard-

HIGH HEADS are an integral part of the giant hydroelectric plants that furnish power to light our homes and run vital industries. Water gushes through tall intake towers when released from lakes backed up by huge dams, and turns mighty turbines, as shown in the sketch below. These operate big generators, developing electricity for transmission over power lines

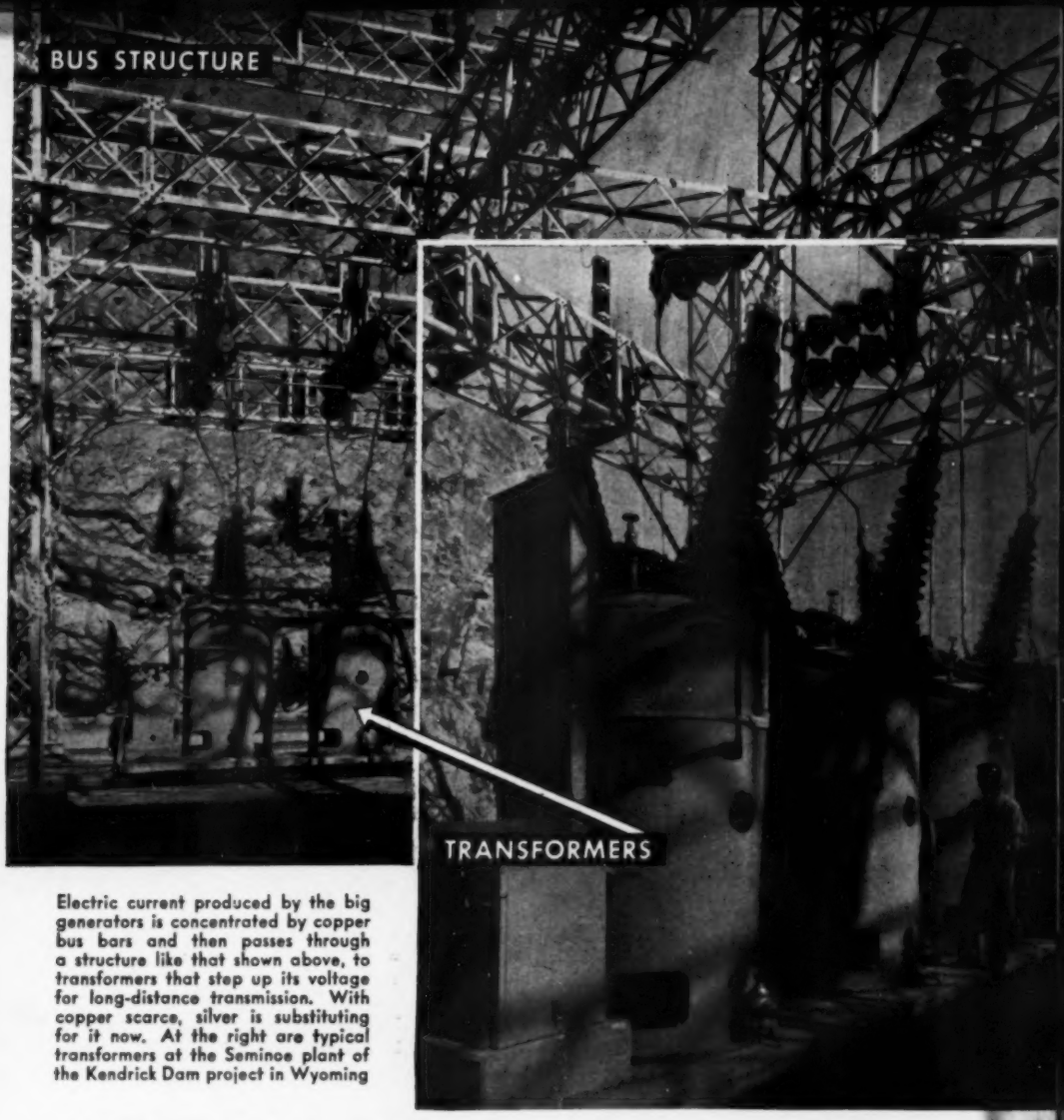
CONCRETE DAM



Nearly seven million tons of concrete went into the construction of Boulder Dam. Immense concrete blocks, laid in vertical columns and locked with steel keys, were sealed together with a special grout to make the vast dam a one-piece structure

GENERATORS

Huge 108,000-kilowatt generators — largest in the world—are installed in the Grand Coulee twin powerhouses. There will be 18 eventually. Each is 43 feet in diameter, 24 feet high, and weighs 1,000 tons. Driving them are 150,000-horsepower turbines, each run by 141 tons of water a second



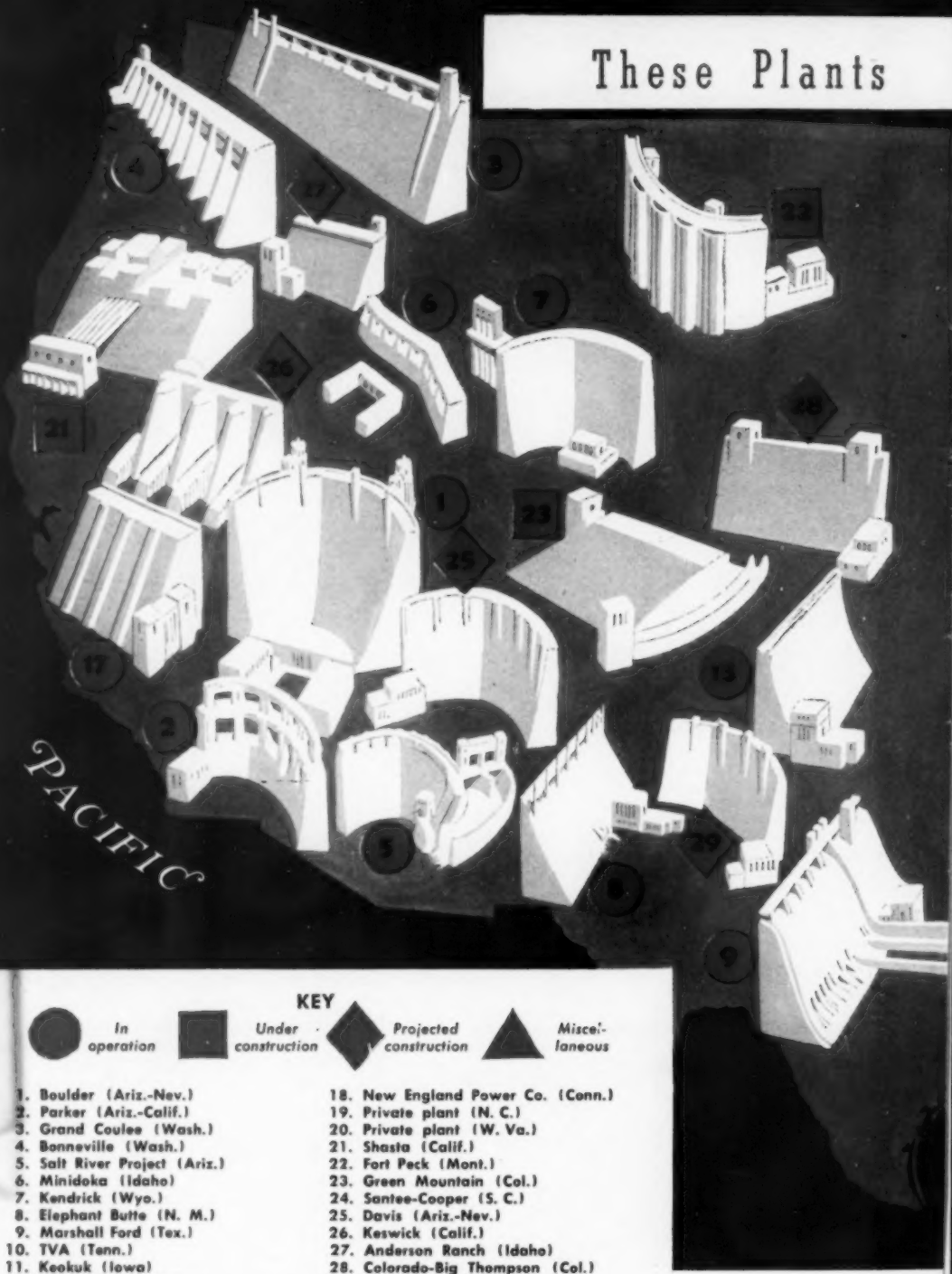
Electric current produced by the big generators is concentrated by copper bus bars and then passes through a structure like that shown above, to transformers that step up its voltage for long-distance transmission. With copper scarce, silver is substituting for it now. At the right are typical transformers at the Seminoe plant of the Kendrick Dam project in Wyoming

ed installations—and the favorite targets of the R.A.F. One bomb neatly placed on a German powerhouse can do more to cut off the flow of arms and munitions to Hitler's war machine than a score dropped on separate factories.

In this battle of the kilowatts, America enjoys an immense advantage in the huge hydroelectric plants that dot the country from Grand Coulee on the Columbia to Boulder Dam on the Colorado and from the falls of Niagara to the valley of the Tennessee. On a thousand rivers and streams, large and small hydroelectric plants add their contributions to the mighty torrent of electric power that is helping us win the war.

Late in 1942 we were using electric power at an all-time high of about 240 billion kilowatt hours a year. Although only 30 percent of our generating plants are hydroelectric, these are producing 40 percent of our electricity. That they are of the greatest importance in our war effort was proved by last year's increases over 1941 in the use of electric power. On the Pacific Coast, where nine tenths of the power generated is hydroelectric and nearly all war industries are served by water-powered plants, the increase was twice the average increase for the nation. The adequate supply of low-cost power assured by hydro-electric developments is an important consideration in the location of war plants. *(CONTINUED)*

These Plants



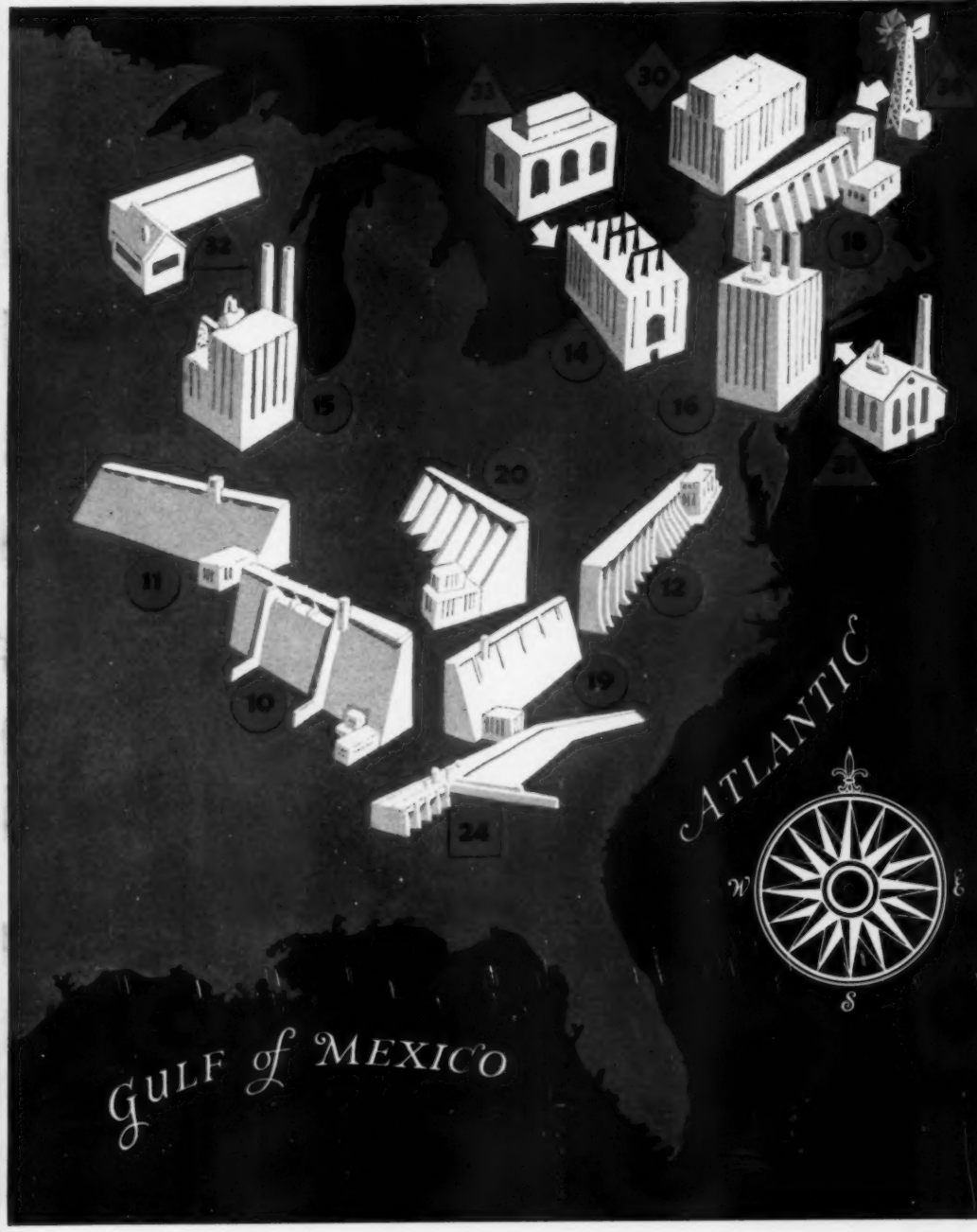
KEY

In operation · Under construction · Projected construction · Miscellaneous

1. Boulder (Ariz.-Nev.)
2. Parker (Ariz.-Calif.)
3. Grand Coulee (Wash.)
4. Bonneville (Wash.)
5. Salt River Project (Ariz.)
6. Minidoka (Idaho)
7. Kendrick (Wyo.)
8. Elephant Butte (N. M.)
9. Marshall Ford (Tex.)
10. TVA (Tenn.)
11. Keokuk (Iowa)
12. Conowingo (Md.)
13. Grand River (Tex.-Okla.)
14. Niagara Hudson Corp. (N. Y.)
15. Commonwealth Edison (Ill.)
16. Consolidated Edison (N. Y.)
17. Pacific Gas & Elec. (Calif.)
18. New England Power Co. (Conn.)
19. Private plant (N. C.)
20. Private plant (W. Va.)
21. Shasta (Calif.)
22. Fort Peck (Mont.)
23. Green Mountain (Col.)
24. Santee-Cooper (S. C.)
25. Davis (Ariz.-Nev.)
26. Keswick (Calif.)
27. Anderson Ranch (Idaho)
28. Colorado-Big Thompson (Col.)
29. Brazos River Authority (Tex.)
30. St. Lawrence Seaway (U. S.-Can.)
31. First steam plant (N. Y.)
32. First hydro plant (Wis.)
33. First big hydro plant (N. Y.)
34. Experimental wind plant (Vt.)

POPULAR SCIENCE

Mean More Power to Uncle Sam



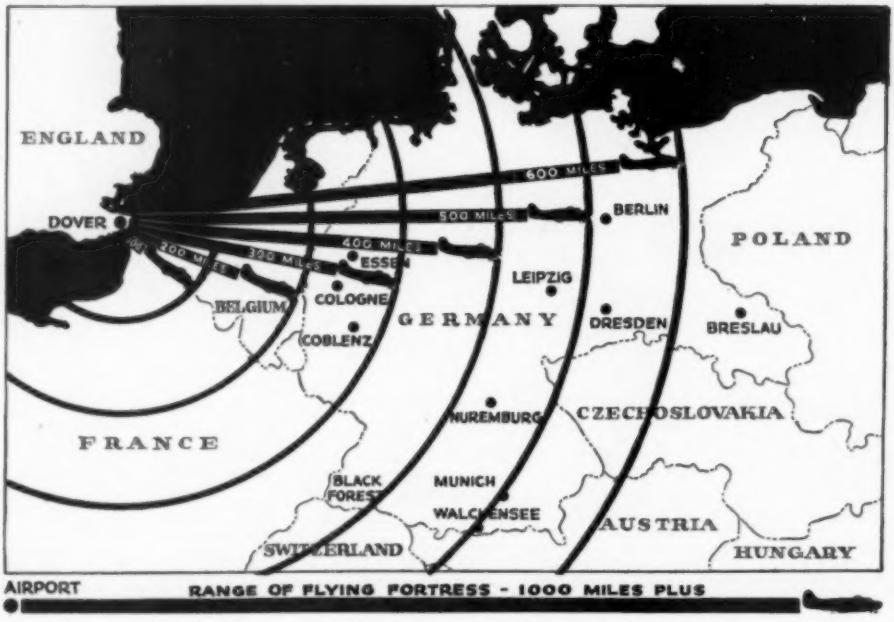
The proportion of hydroelectric generating plants is increasing steadily. Since the earliest days of the 60-year-old electric power industry generators have been driven by both steam and water. Thomas A. Edison opened the first steam-powered central station on Pearl Street in downtown New York in September of 1882, and a few days later opened the first hydroelectric plant on the Fox River at Appleton, Wis. But until about 25 years ago, because of the then unsolved technical difficulties and high cost of transmitting electric current over long distances, hydroelectric development had to be confined largely to localities where water power was fairly close to potential users of the electric power to be generated by it. Consequently, more steam than water-power plants were built. But methods have been improved until electric power can be transmitted economically for 300 miles, and now half of the power-producing facilities under construction are hydroelectric—nearly all of them Federal or state owned.

Drillers at work on one of the dams in the network of TVA hydroelectric plants on the Tennessee River and tributaries

Hydroelectric plants are expensive to build, but once built they cost much less to operate than do steam plants. Little labor is needed to keep them running, they burn no coal, and their economic life is much longer than the 20-year average of steam plants. Their most serious disadvantage is that sometimes their power output is lessened by droughts, but on many rivers storage dams built upstream from the power dams assure uninterrupted production.

The hardest-to-break wartime bottleneck in increasing hydroelectric power produc-

Nazi power plants are highly vulnerable to bombing attacks from planes ranging from the air fields of England. Unlike this congested layout, power plants in the U. S. are spread out over a wide territory



Boulder Dam backs up water of the Colorado River to form the world's largest man-made lake and produce power for warplane plants as far away as Los Angeles

tion is the procurement of turbines and generators. They take about two years to build and there are only a few manufacturers who have the equipment and highly skilled workers necessary for the job. Unfortunately, these manufacturers also are the only ones who can build steam turbines for warships and cargo vessels, and the War Production Board has ordered work stopped on all powerhouse equipment that will not be finished by early next year.

The mammoth dams which tame and harness mighty rivers for the generation of electric power are among the most impressive of the works of man, and their building is made possible only by brilliant pioneer work in engineering. The two most spectacular are, of course, Boulder Dam on the Colorado River near Las Vegas, Nev., and Grand Coulee on the Columbia in the state of Washington. One is the largest individual power plant in operation anywhere in the world; the other, when completed, will dwarf it.

Boulder Dam is geared now to a generating capacity of 952,300 kilowatts with 12 of its projected 17 generators in action. It produces over 3 1/3 billion kilowatt hours of current annually, transmitting much of it to plane factories in the Los Angeles area over a 266-mile 285,000-volt double-tower line—longest in existence and unparalleled for high voltage. Grand Coulee, in operation only since 1941, has a present capacity of 386,000 kilowatts, and two more 108,000-kilowatt generators will go into service this year. When all 18 are installed, Grand Coulee will have a capacity of close to two million kilowatts, or 13 billion kilowatt hours a year. It is the biggest engineering structure that has ever been built by mankind.

The 115,000-horsepower turbines at Boulder Dam are turned by water gushing through four skyscraper-high intake towers from Lake Mead, the largest man-made reservoir in the world. Grand Coulee's 150,000-horsepower turbines are fed by the overflow of a 1,650-foot spillway which forms a waterfall twice as high as Niagara.

And both these great plants are but units —though the most impressive—in their systems Boulder Dam is supplemented by Parker Dam, 155 miles downstream, and Davis Dam, midway between them, will be finished after the war. Grand Coulee is interconnected with Bonneville Dam, completed by Army Engineers in 1938 at the head of tidewater on the Columbia. Seven more dams are proposed to raise the Columbia output to the *(Continued on page 216)*

Morale in Boxes

Recreation kits bring our soldiers the entertainment they used to have at home

"A" kit is for the soldiers who like to swing a bat, punt a pigskin, or dribble a basketball. Among other items, it contains baseball equipment, a football and inflator, a volley ball and net, boxing gloves, a number of softballs, several books on sport, and also a repair kit

BECAUSE all work and no play can soon make the best soldier in the world a poor one, the Army's Special Service Division—morale builders for our fighting forces—have prepared a dozen kinds of recreation kits to provide our troops both here and abroad with entertainment ranging all the way from a game of chess to seeing the latest "oomph" girl on the screen. Kit "F," for instance, which is distributed in the ratio of one to every 300 men, contains, among other items, chess, checker, parcheesi, domino, cribbage, and backgammon sets; 36 packs of playing cards, a set of poker chips, and a pair of dice. Kit "J" carries complete equipment for the showing of sound pictures—including Hollywood's latest releases. Kit "B-1" has a

Army information films, newsreels, and Hollywood releases are projected for soldier audiences by Special Service's trained operators

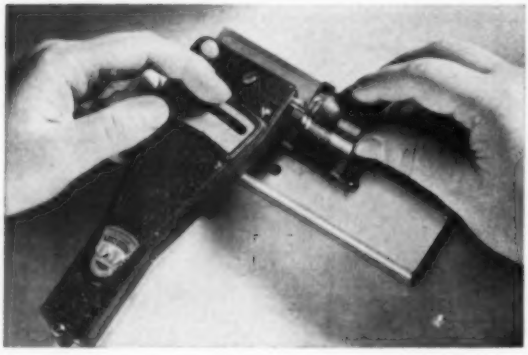
Above is a rear view of the loudspeaker used in the public-address system. Below, a technical sergeant prepares to regale the boys with "canned" music both sweet and hot

radio, phonograph, and public-address system. Kit "D" packs a dozen musical instruments including guitars, violins, harmonicas, and a baby grand piano. In "E" kit are all the "props" and grease paint an amateur theatrical might require, while in "I" the boys will find complete equipment with which to put out a mimeographed newspaper. For the lads who like to "stay home at night and read," Special Service puts out "C" kit—a library of 2,000 books.

From kit "D" comes this baby grand piano which is only 40 inches high, weighs but 500 pounds, has a standard keyboard of 88 notes, and a tone admirably suited to such wartime songs as "Don't sit under the apple tree with anyone else but me"

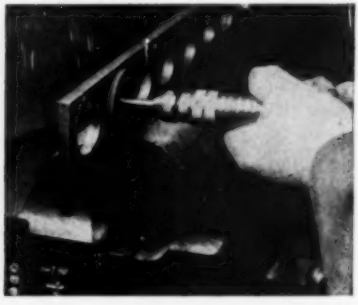
new Tools

A BRUSH ATTACHMENT for use on a drill press makes a quick job of cleaning out drilled holes and recesses cut in metal work, removing burrs, sharp corners, dirt, and chips in one operation of the press. It is disk-shaped, as shown in the photograph at right, with one side and the bottom edge flattened. This design has been found efficient for cleaning the side walls and the bottom of the cavity at the same time. The shank of the brush is inserted in the chuck of the drill press, and the machine is then operated as it is for drilling.



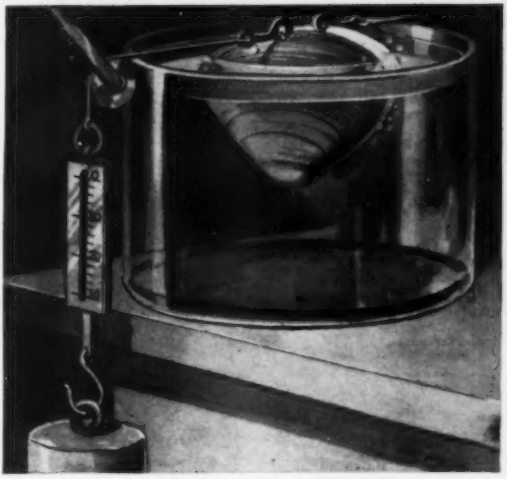
BRAILLE MARKINGS have been added by one manufacturer to his gauge for comparison inspection of precision parts, making possible the employment of capable blind persons in a branch of industry where their sense of touch should be valuable. The gauge itself works on the principle of multiplying measured distances and transferring them to an indicator after adjustable contact points have been set to tolerance limits from master parts. It was designed for visual recordings before the Braille scale was added.

SLOTTED ABRASIVE-CLOTH DISKS reduce considerably the operations in burring and polishing holes in metal. A disk of larger diameter than the hole is mounted on a mandrel and used with a high-speed electric, air, or flexible-shaft tool. It is pushed into the hole and pulled out again, producing a perfect radius and removing burrs at the same time. Two disks back to back remove burrs from both edges of a hole in one operation.

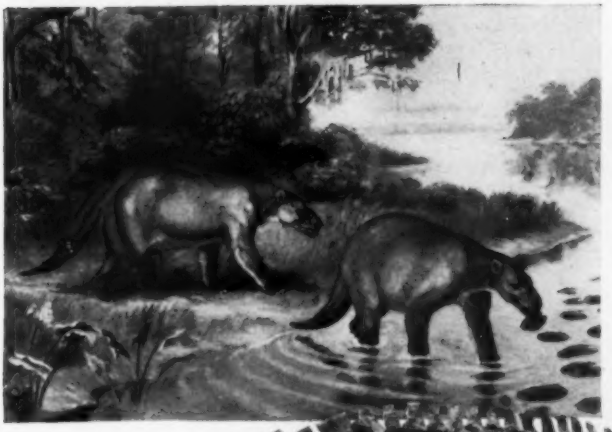


Bivalves Set Good Example for Wartime Rumor Spreaders

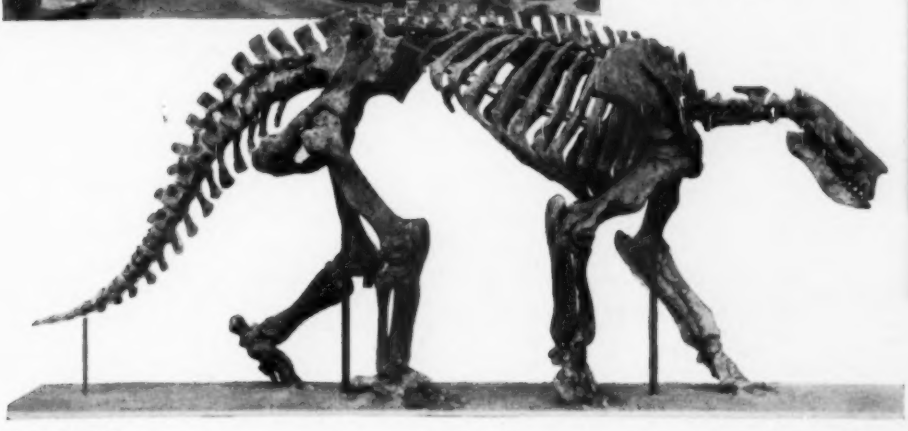
CLAMS and oysters can "clam up" so tightly that they are able to keep their shells shut for days against pulls of many times their own weight, reports Prof. A. M. Reese of West Virginia University. Professor Reese made use of hooks, pulleys, and weights, as illustrated, and kept the bivalves alive in a salt solution approximating sea water. The weights he used ranged generally from one-half pound to two pounds, and the shellfish were kept under a continuous tension lasting as much as five days. One oyster was subjected for two days to a three-quarter-pound tension which was then gradually increased. The oyster remained closed until the tension reached 22 pounds, and then finally yielded only when its shell-closing muscles were torn apart.



Museum Skeleton Shows How Large Mammals Got Their Start



A SKELETON of *Barylambda*, a hoofed mammal that roamed swamps in Colorado 50,000,000 years ago, has been placed on exhibition at the Field Museum of Natural History in Chicago. Shown as it looked in life in the artist's reconstruction at the left, this prehistoric animal is of special interest because it was one of the first large mammals to appear after the passing of the dinosaurs and other giant reptiles. *Barylambda* stood about four feet high.



Flying Sharpshooters

HERE'S WHAT HAPPENS IN THE FIVE WEEKS THAT TURN A GREEN HAND INTO A CRACK AIR GUNNER

By ANDREW R. BOONE

WHEN you read of American aerial gunners scoring amazing victories over Axis fighters, do so with the realization that many of them, only a few months ago, had never even seen a machine gun. Intensive, thorough training has given them the skill of veteran air fighters.

Our gunners fortunately are blessed with good shooting eyes. They spring from fathers who have handled rifles since early boyhood. Even without long, hard training in the art of shooting, they're more than a fair match for our enemies.

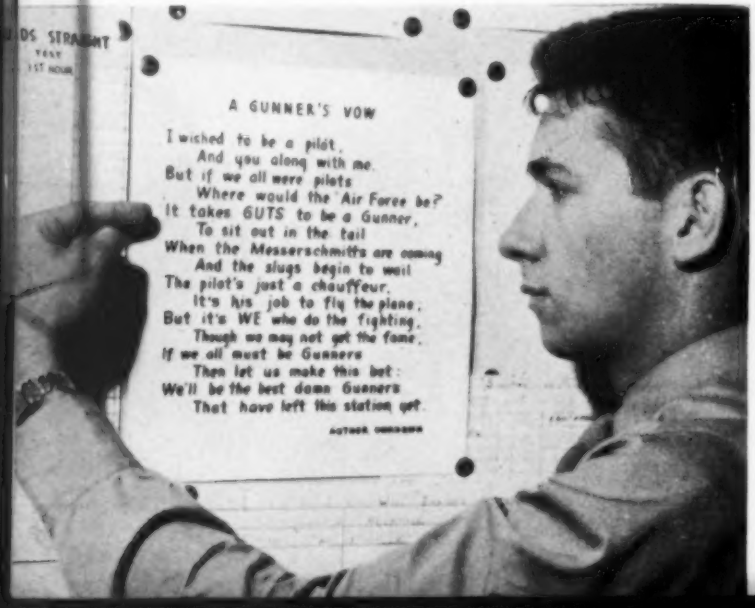
But I'd like to present an even more encouraging picture. Recently I spent several days at McCarran Field near Las Vegas, Nev., one of the Army's schools for training in flexible gunnery. There I observed students, all volunteers, in every stage of the rigorous five-week course as youngsters fresh from replacement centers labored and sweated to win their precious sergeant's stripes and gunner's wings. There I observed in the making the smashing victories that will make tomorrow's news headlines.

Talk to any gunner who has experienced the withering fire of a German or Jap, and he'll tell you our boys are better than their opponents.

Sergt. Hamilton Moore rode the clattering tail of a Flying Fortress to help beat back the Jap fleet at Midway. Together with Paul Johnson, a staff sergeant manning the upper turret, he knocked off four Zeros on one flight, filling them with .50 calibers at 300 to 450 yards. Moore and Johnson went up with 1,200 rounds of ammunition, came down with 800 remaining in their belts. Four hundred rounds, four Zeros!

From every front, word comes back to the schools that American gunners are taking a terrific toll of the enemy. The guns of a Flying Fortress dropped three Sento Zero Zeros off Alaska in six seconds. Over France a Fortress exploded a German fighter at 1,200 yards, a distance normally considered beyond the effective range for the .50 calibers.

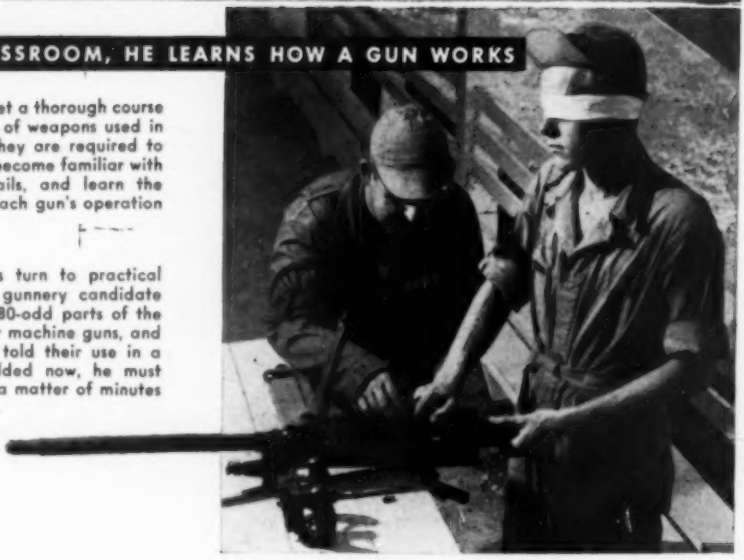
When a gunner roars into combat, his shooting job calls for the automatic solu-


A GUNNER'S VOW
I wished to be a pilot,
And you along with me.
But if we all were pilots
Where would the Air Force be?
It takes GUTS to be a Gunner,
To sit out in the tail
When the Messerschmitts are coming
And the slugs begin to wail
The pilot's just a chauffeur,
It's his job to fly the plane,
But it's WE who do the fighting,
Though we may not get the fame.
If we all must be Gunners
Then let us make this bet:
We'll be the best damn Gunners
That have left this station yet.

Boys in the flexible gunnery schools claim this vow is not exactly true—that being a trigger man on a plane is often a first, not a second, choice. A plane's flexible guns are not the province solely of the gunners. Bombardiers and navigators too are taught how to shoot them fast and straight. Evidence of how well they learn is the record recently set by a Flying Fortress crew—three Jap fighters knocked out of the sky in six seconds. At right, the tail gunner in a Mitchell bomber mans his .50 caliber gun

IN THE CLASSROOM, HE LEARNS HOW A GUN WORKS

Student gunners get a thorough course covering all types of weapons used in aerial gunnery. They are required to take them apart, become familiar with the minutest details, and learn the principle behind each gun's operation



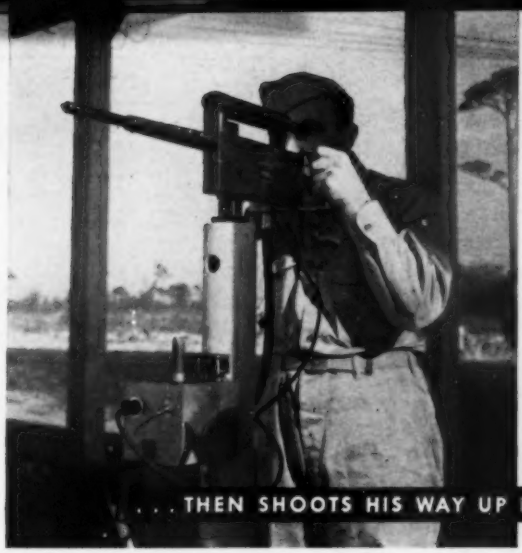
And then lectures turn to practical application. The gunnery candidate has learned the 180-odd parts of the .30 and .50 caliber machine guns, and named them and told their use in a stiff test. Blindfolded now, he must assemble them in a matter of minutes

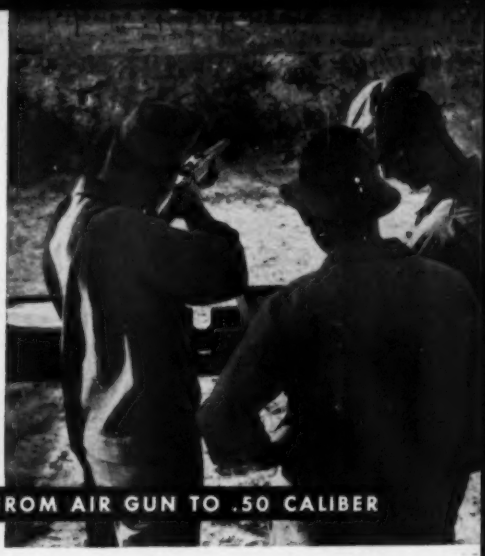
tion of several triangles. Were he to halt for even a second to think about the problems, the enemy might shoot down the bomber he's guarding.

Psychologists are just now taking over the vastly important job of conditioning him for such moments. Every one of the 35 days in gunnery school witnesses one more strand of the pattern woven into training and habits.

You'd be amazed to see recruits awkwardly fingering a BB gun one Monday and tossing off glibly five weeks later such terms as exterior ballistics, apparent speed, and range estimation, then winding up with a sharpshooting demonstration by plugging a fluttering white target from the after cockpit of a gunnery plane or the belly turret of a Fortress.

What has occurred meanwhile? First, they have learned by trapshooting to aim and lead a target, winging clay birds as





. . . THEN SHOOTS HIS WAY UP FROM AIR GUN TO .50 CALIBER

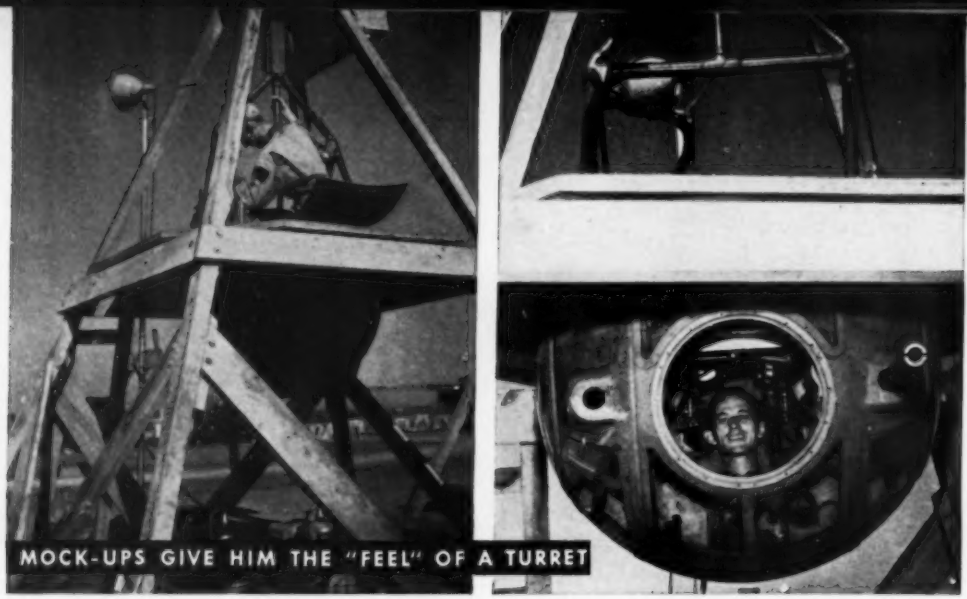
A compressed-air machine gun firing BB shot gives the embryo gunner his first practice in handling a gun and following a moving target. It fires a full package of shot with one loading, and is fairly accurate at 50 feet

From air guns, the student gunner goes to hand-held .22 caliber rifles, firing away at moving airplane targets similar to the ducks in a Coney Island shooting gallery

At a skeet range, the tyro is under the watchful eyes of champions. He learns how to make snap decisions in sighting and how to follow through on the swift targets

A water-cooled .22 caliber machine gun, used on targets at simulated airplane speed, adds training in control and not firing too long a burst

On the harmonization range, lower right, the boys learn to hold the bucking .30 and .50 caliber guns on a sight



MOCK-UPS GIVE HIM THE "FEEL" OF A TURRET

Having learned all about guns and, most important, how to shoot them, the young gunner finds out what sort of place he will call home in an air battle. Here he slides into a Sperry ball, the belly turret on a Fortress, going in through a hatch in the floor

It's a snug berth. Once in, a man can lie down on the job—but he won't "lay down" on it. There is no room for standing, or even for crouching, and the gunner must do all his sighting and shooting while flat on his back

they speed straight away, to right and left.

Then, on a moving-base range, they continue skeet-shooting from trucks bumping 15 miles an hour around a mile-long track. Now the birds wing in all directions. A good shot will hit ten out of 25 during his first round.

Aim, lead, and fire. That's the eternal pattern. Now the embryo gunner advances to hand-held .30 caliber machine guns. He looks across an oval track, around which a gas-powered car carries a white target, passing alternately 100 and 400 yards from the guns. Aim high, lead, and fire. Painted bullets will reveal the score.

Near by the boys practice range estimation, peering through standard sights along wooden guns mounted on a long railing. Every minute or so an attack plane roars in, swishing past their sights only 50 feet up. Over the radio they hear: "One mile . . . one thousand feet . . . eight hundred

Tracer bullets streak out in the night as fledgling gunners pump away at a moving target high above an Army jeep. They have already had their turn at day firing and, as the tracers and one of the photos on the facing page show, are proficient in marksmanship. Jeep and driver are protected by an embankment

This is the Martin upper turret on the B-26. It mounts two powerful .50 caliber machine guns so arranged, with gunner and common sight between them, that they take less space than old models with smaller guns. They revolve automatically

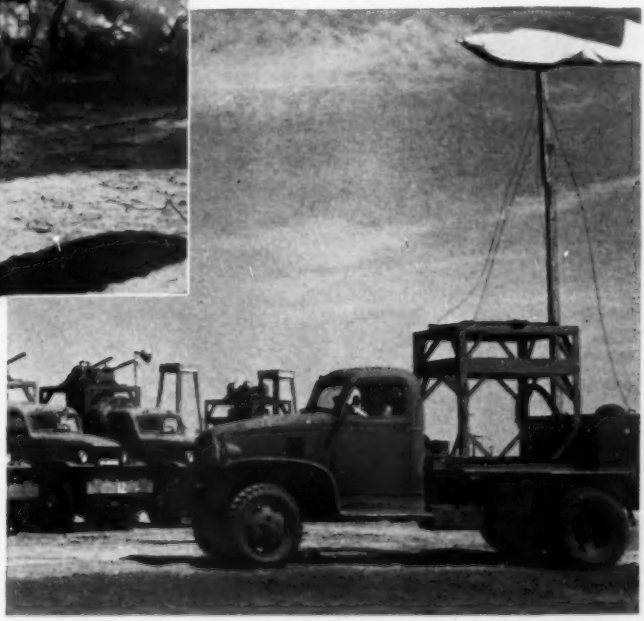
. . . six hundred . . . four hundred . . . two hundred." Shortly every man on the line knows how that 60-foot span looks in his ring sight at all ranges.

Now the boys get their first taste of the big .50's. They crawl awkwardly into powered turrets—the kind they'll fight from in the Fortresses and Liberators—mounted on heavy trucks, and train their weapons on the same white targets. You note they wait longer before touching the triggers, and fire shorter bursts. They want every possible shot to count.

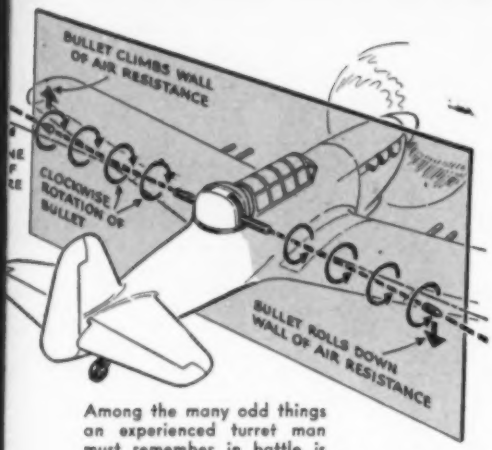
During the final week, having mastered ground-range firing, from both swivel-mounted and turret guns, the students climb daily into planes for aerial firing. Those who pass successfully receive combat-crew wings and sergeant's stripes, and are assigned to teams for final training before going into action.

How well a gunner performs in combat depends both upon his training and the ring sight through which he views the darting enemy plane. He times the target across, and the angles take care of themselves.

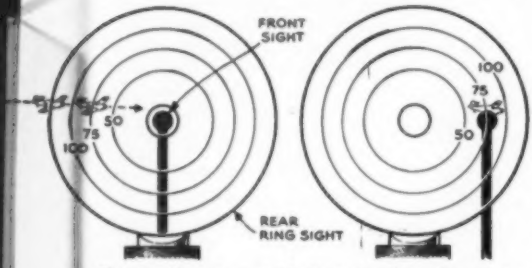
This adds up to what he knows as relative or apparent speed, determination of which requires that he know the range and the length of time required for a target moving at a definite speed to cross the ring. As he grows more familiar with various approaches in aerial combat, he is able to



Proof of marksmanship is the target plane above, pitted from machine-gun bullets and patched for another "flight." The gunners use bullets with painted tips, and their hits are chalked up in distinguishing colors so each man's score can be recorded. At the right, a model Messerschmitt mounted on a truck for turret shooting on a course like the jeep's



Among the many odd things an experienced turret man must remember in battle is that bullets fired to the right of a swiftly moving plane have a tendency to drop, those fired to the left tend to rise. Bullets spin clockwise, and friction from the right-angle wind exerts force on the top of the former, the bottom of the other



This is the ring sight that teaches the novice gunner to lead his target. He watches the flight across the miles-per-hour rings and calculates the speed. Then he draws his bead ahead of the plane, in this case on the 75-miles-per-hour ring

estimate that speed by observing only momentarily the flight of a plane across his ring.

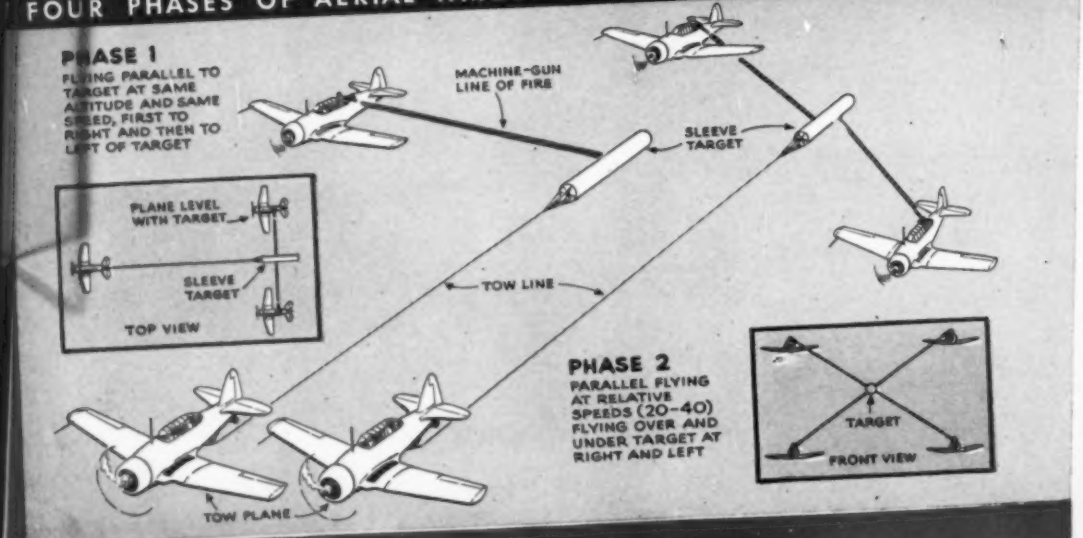
Another reason why aerial gunners must undergo rigid training is that bullets don't behave as they would if fired in the still air of an indoor range from a stationary position into a stationary target. Not only does gravity pull a .50 caliber projectile down and air resistance hold it back by measurable amounts which vary with altitude, but the surrounding air causes the bullet to drift upward when fired to the left of the plane, right when shot upward, down when discharged to the right, and left when shot downward.

Too, the very rush of the plane forward imparts a sideways movement to the bullet until air resistance causes it to straighten out and actually lag behind the firing plane.

Wind rushing past further complicates aim, bringing into play a third factor called ballistic deflection. This means the gunner must actually lead the target by an additional amount, depending upon the angle at which he fires.

Few military experts thought two years ago that aerial gunnery as exemplified by American crack shots would account for a high percentage of hits at ranges exceeding a half mile. Then the .50's commenced proving their worth, Germans and Japs became wary of moving in too close, and air battles raged with fighters pot-shooting from 600, 800, and 1,000 yards, sweeping in for quick passes at closer ranges. But the .50 caliber is still deadly against these tactics. With a well-trained man behind it, it can throw 400 to 600 slugs a minute into a hat at 3,000 feet. And that's shooting!

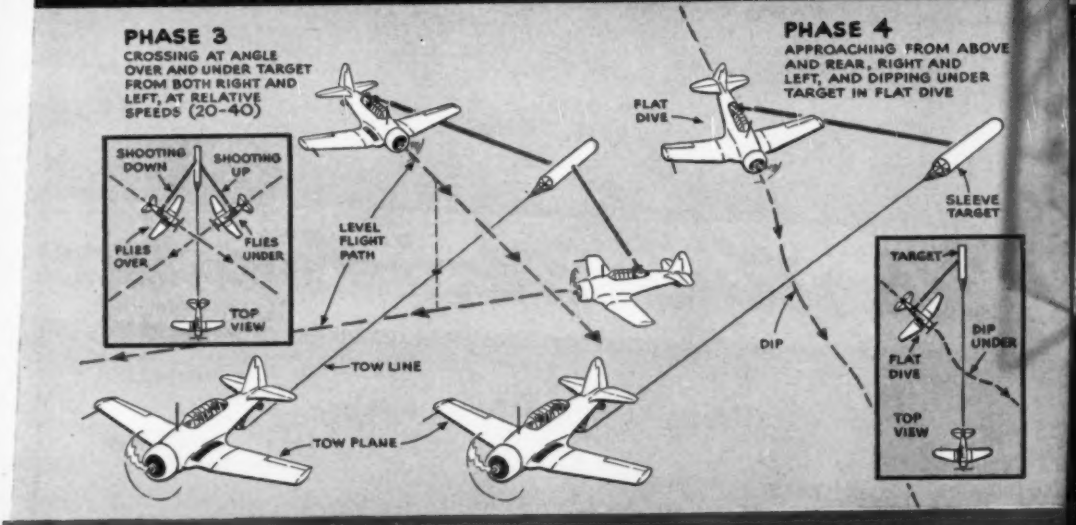
FOUR PHASES OF AERIAL TARGET PRACTICE TEACH GUNNERS

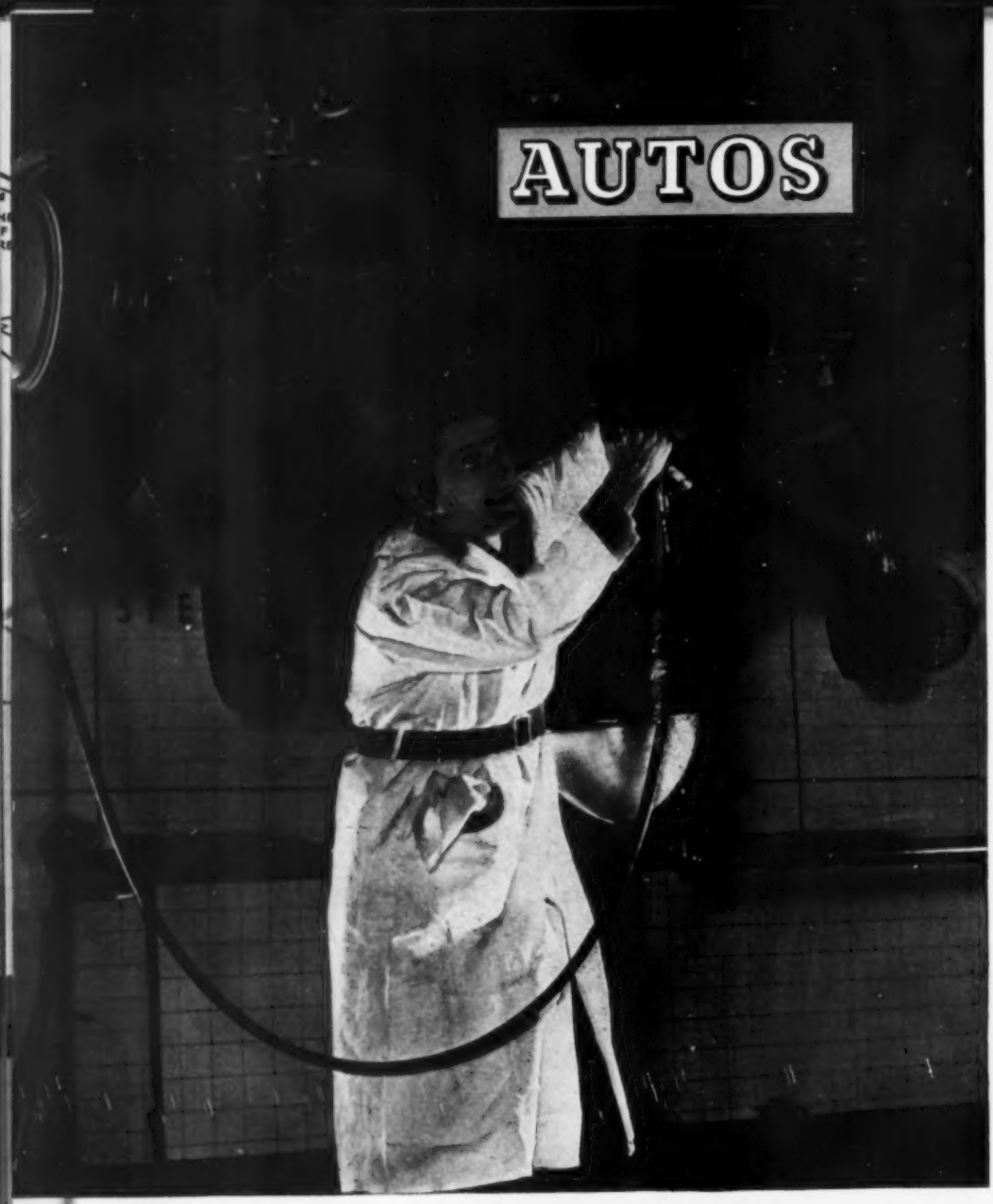

PHASE 1
FLYING PARALLEL TO TARGET AT SAME ALTITUDE AND SAME SPEED, FIRST TO RIGHT AND THEN TO LEFT OF TARGET
MACHINE-GUN LINE OF FIRE
SLEEVE TARGET
PLANE LEVEL WITH TARGET
SLEEVE TARGET
TOP VIEW
TOW LINE
TOW PLANE
PHASE 2
PARALLEL FLYING AT RELATIVE SPEEDS (20-40) FLYING OVER AND UNDER TARGET AT RIGHT AND LEFT
TARGET
FRONT VIEW

IN THE AIR, HE SHOOTS AT A TOWED TARGET

Hardly a novice any longer, the student heads toward the payoff when he climbs into a plane in the fifth and final week of the stiff gunnery course. He shoots now at a towed target, attacking it from every conceivable angle, as shown in graphic detail in the drawings below. In the end, he is moved up automatically to get his sergeant's stripes and his coveted gunner's wings. The next step is to take a place in the combat team of a bomber and practice his art on a Zero or a Focke-Wulf. The boy is ready

TO HIT ENEMY PLANES FROM VARIOUS ANGLES OF APPROACH





Wartime Maintenance

By RALPH ROGERS

GASOLINE rationing and the national speed limit of 35 miles per hour make it increasingly important for car owners to adopt a systematic plan of inspection of the many small items that are frequently taken for granted in a car. Attention to these points on a regular periodic basis will make replacements less necessary and will be a big help toward making the old bus live a serviceable life for the duration.

It sounds paradoxical to say that less driving increases the rate of deterioration of moving parts, but it is nevertheless true. This can best be avoided if cars are inspected and lubricated on a time basis—bimonthly, for example—rather than at the mileage intervals to which most drivers have been accustomed.

Since most car owners are in the A-card class, the use of their cars is naturally confined to driving to the station, taking children to school, shopping, and similar small but necessary chores. These trips are usually short, and as a result the engine is operating "cold" too much of the time, thereby increasing water condensation.

Lower engine temperatures, especially in winter, reduce the efficiency of crankcase ventilation so that the steam in the exhaust gas that blows by the pistons condenses to water. This water mixes with the oil to form a thick sludge that impedes the flow of lubricant. It also hardens on pistons and valves, causing them to stick. Lubrication failure and serious engine damage often follow oil sludging. There is still another danger in this. Exhaust gas blowing by the pistons into the crankcase dissolves in the water and forms very corrosive acids that may seriously damage engine parts.

Therefore, corrosion, sticking parts, sludge formation, oil dilution, and kindred evils are all hidden enemies doing their dirty work in the dark. To defeat these enemies, we suggest the following plan of attack.

Engine Oil. The cheapest insurance against rapid wear of engine parts is to use a high-quality, 100-percent petroleum oil of the correct viscosity, made by a reputable refiner. Compounded oils should not be used as they have a detrimental effect on certain types of engine bearings.

When selecting an oil, it is good practice to be guided by the recommendations of your car manufacturer as to its viscosity for any given temperature range within which the car is generally operated.

Chassis Lubrication. High-quality lubricants of the right kind will keep the various units of your chassis operating dependably. While the initial cost of an inferior lubricant may be lower, it has been proved by fleet operators that maintenance cost increases when a poorer grade is used. With this in mind, always have your car serviced by a dealer who handles high-quality products.

Cooling System. Since the cooling system must dissipate the heat of the engine under severe operating conditions, and also control the operating temperatures during cold weather, the fan, water pump, radiator, and thermostat must function as one unit.

Make a systematic, periodic inspection of all hose connections to prevent leaks, replace any hose that is likely to impede water circulation, check the fan-belt adjustment to prevent overheating, test the thermostat by immersion in a pail of heated water (the opening temperature is usually stamped on the thermostat), and have the radiator and engine flushed at least twice a year—preferably in the spring and fall.

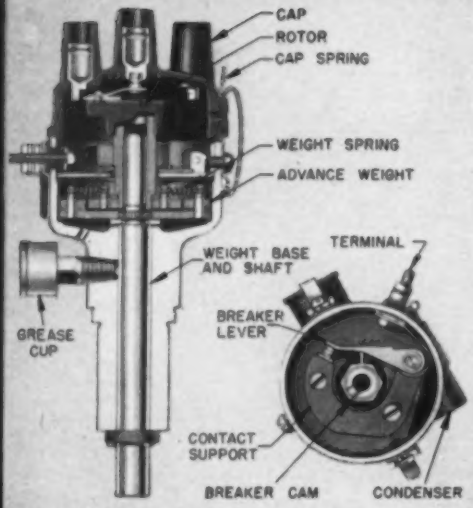
Spark Plugs. Plugs should be inspected at regular intervals. If necessary, clean them and set the gaps according to the recommendations of the manufacturer. Plug gaps that are too wide will cause hard starting and poor top-speed performance; those set too close will result in poor idling and low-speed operation. When spark plugs are replaced, it is important that they make a good, tight contact with the cylinder head, but if they are tightened too much, there is danger of changing the gap.

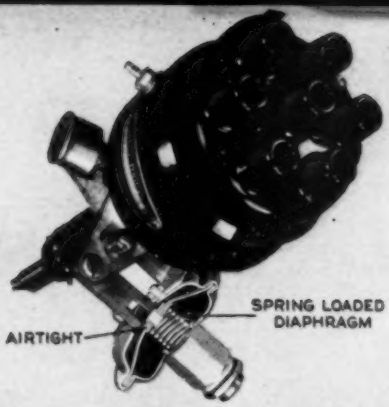
Ignition. Improper ignition timing can put a big dent in your gasoline allotment. It is well to have your ignition distributor looked over every once in a while by an ignition expert to eliminate guesswork and obtain best results.

If you prefer to do the job yourself, make sure the points are clean, seated squarely

for Your Car . . .

RATIONED DRIVING CALLS FOR SERVICING ON A TIME BASIS INSTEAD OF BY MILEAGE





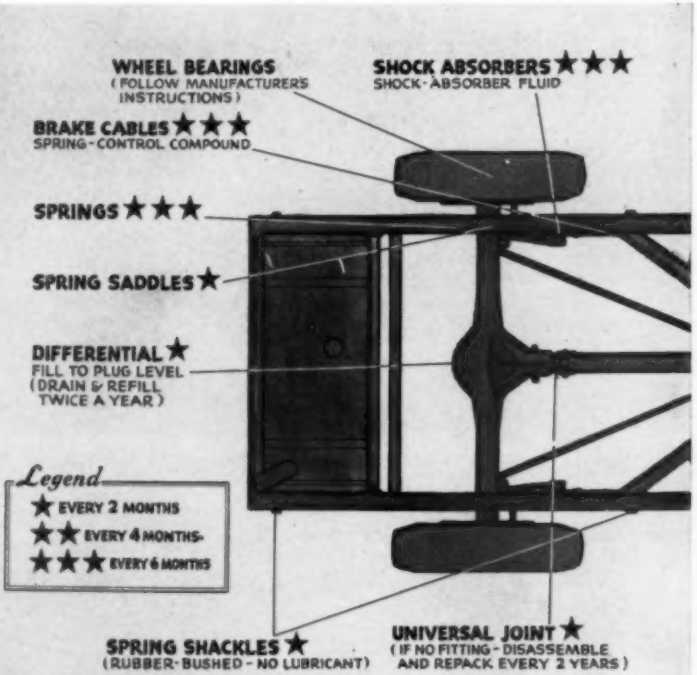
The working parts of a vacuum advance unit are shown above. This unit advances the breaker plate only at intermediate speeds, and would waste gas because of a retarded spark should the diaphragm be broken or carbon restrict the vacuum line. At left is a cross section of a distributor. Check the molded parts for cracks, chips, and burned places, and keep the internal mechanism free from dirt, oil, and water

on each other, and adjusted to the proper opening, according to the manufacturer's specifications. Examine the distributor cap for cracks, check the condition of the rotor and wires, and make sure that the internal mechanism is free from dirt, oil, and water.

Should your ignition system be equipped with a vacuum advance unit, check this for proper operation. To determine whether or not the unit is functioning, turn the engine over with the starter while holding the choke closed. If the distributor plate advances and returns, the vacuum unit is in good condition. If the diaphragm is

CHART FOR SERVICING AUTOMOBILE CHASSIS

Two months represent 1,000 miles of normal driving before gas rationing, so if you have a B or C card, it may be better for you to stick to a mileage basis for servicing. Besides following the chart at right, there may be some special points to watch. If oil shows up thick and dirty on the oil-level rod, the oil filter should be serviced. To lubricate covered springs, remove the cover in order to get lubricant in; if the leaves are provided with channels for the lubricant, put it in through the fittings in the center bolts. Uncovered springs are cleaned thoroughly and oiled. Distributors provided with a wick under the rotor will require a few drops of oil on the wick every 60 days or 1,000 miles



broken, the distributor plate will not advance. If the distributor plate advances but does not return, the spring is broken.

After setting the ignition timing according to the manufacturer's instructions, take the car out for a road test. For best performance and fuel economy, set the distributor advance arm so that the engine will "ping" slightly when the throttle is opened wide at comparatively low car speed, bearing in mind, of course, that spark-plug gaps should be set properly and the engine warmed up to its normal operating temperature.

Battery. Corroded battery terminals and loose or dirty ground connections shorten the life of a battery and keep it from delivering full power or receiving the maximum charging current. Whenever necessary, the terminals should be cleaned with a strong solution of ammonia and water, and coated with petroleum jelly afterwards.

Each battery cell should be tested frequently with an accurate hydrometer. Never make this test immediately after adding water, for this will give a false reading. Distilled water should be added when necessary, but only enough to bring the fluid level to about ⅜" above the plates.

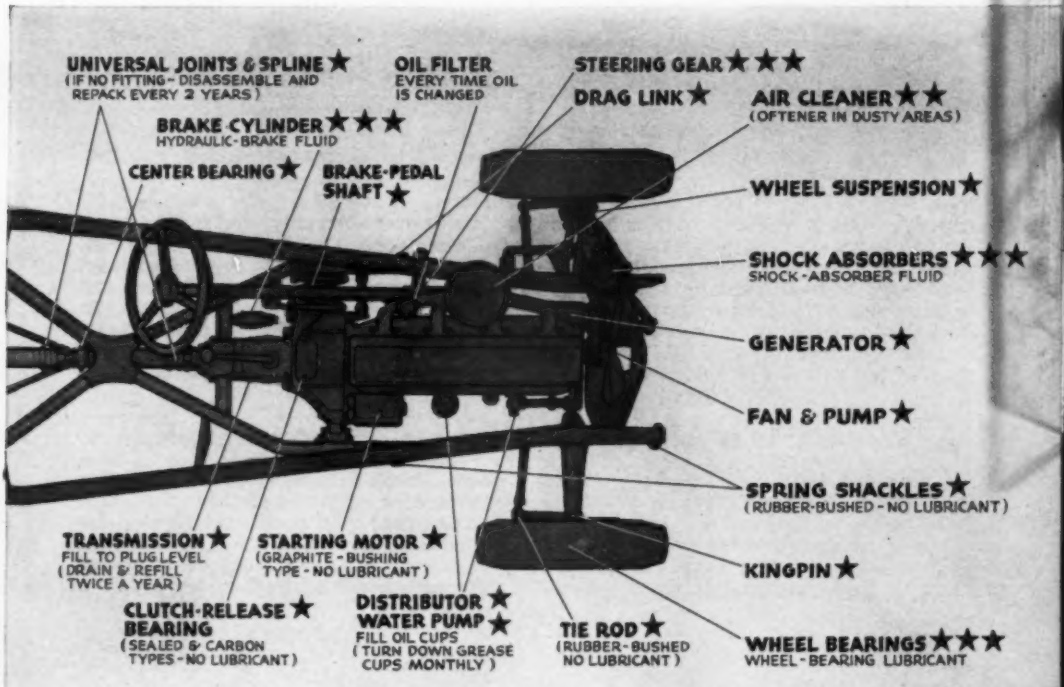
Since less driving under your gasoline ration probably means more starting and shorter trips, the rate of battery discharge will increase while the rate of charge goes down. It might be wise to have your generator advanced slightly so as to offset this partially by a higher rate of charge. If you have a small battery charger, you might plug the battery in occasionally when your car is in your garage. As an alternative, have the battery checked more frequently by your battery serviceman and charged as often as necessary.

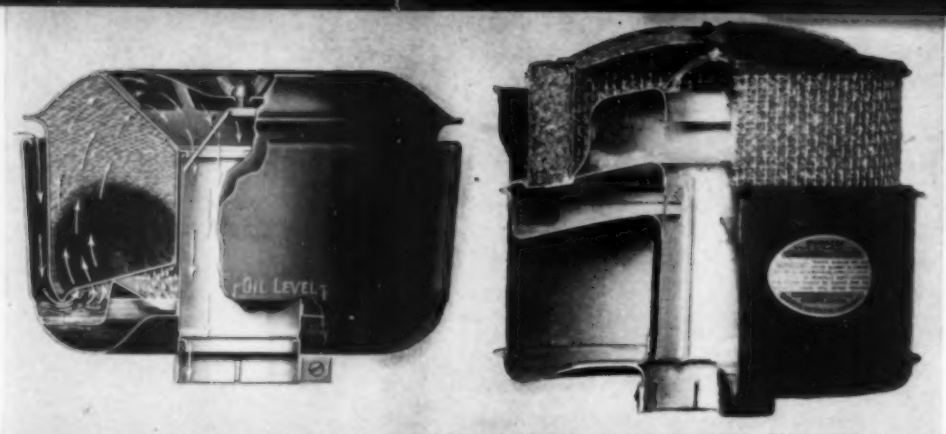
If the battery cells are in good condition but are continuously in a partially discharged state, the generator and regulating device should be checked and adjusted by a competent auto electrician who is equipped to do the job correctly.

Carburetion. Present-day carburetors are of the fixed-jet design, and all mixture adjustments, except idling, are controlled by the sizes of the various jet orifices. The carburetor should be removed, disassembled, and cleaned, if satisfactory performance of your engine cannot be obtained and you are reasonably certain that the difficulty does not lie in the engine itself or in the ignition system.

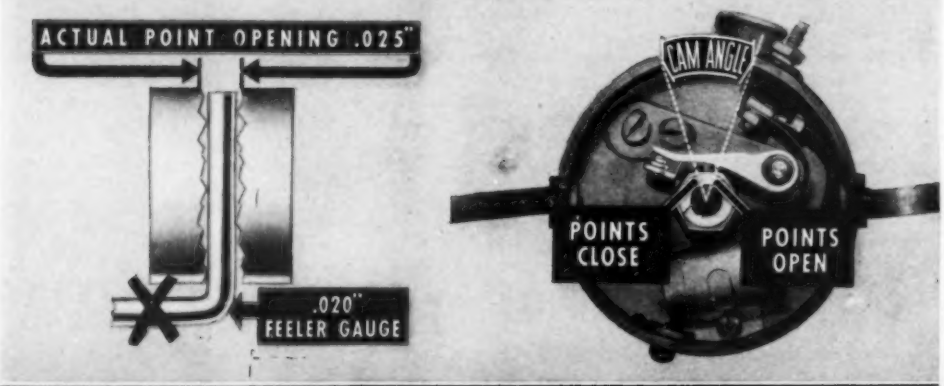
After replacing the carburetor, but before adjusting the idling mixture, warm up the engine until the intake manifold is at least warm to the hand. Then turn the idling adjusting screw gradually to the right or left until the engine runs steadily at the desired

ON ELAPSED-TIME BASIS FOR A-CARD DRIVING





Principles of the operation of air cleaners are shown above — a typical oil-bath type at left and a dry type at right. Dirt clogging the cleaner will restrict the flow of air to the carburetor, resulting in an overheated engine, increased fuel consumption, crankcase dilution, and inefficient performance



Don't use a feeler gauge to measure the opening between points unless the points are new or are not rough. As illustrated at left, this gauge may give only the measurement between the high points. The correct opening can be determined here by using a dial indicator mounted on the distributor or a cam angle meter. Cam angle, as shown at right, is the number of degrees the breaker points remain closed during breaker-cam rotation. Setting the points on a meter measuring this eliminates guesswork

throttle position. If the carburetor is of the double-barrel type, adjust one barrel at a time. Turn the screw slowly until the engine begins to run irregularly, and then turn it in the opposite direction until it begins to "lope." A point midway between the "irregular" and the "lope" is what you want. Repeat this with the other adjusting screw.

Air Cleaner. Dirt clogging the air cleaner will restrict the air flow to the carburetor, resulting in an overheated engine, increased fuel consumption, crankcase dilution, and general inefficient engine performance. To prevent this, periodic air-cleaner servicing must not be neglected. Watch this especially if you drive in dusty or sandy areas.

Wooden Tires Replace Hard Rubber on Tractor Trailers

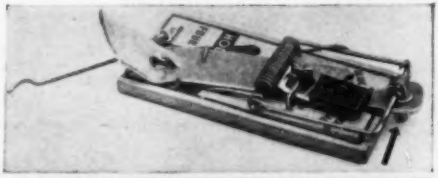
ONE industrial concern—the Federal Shipbuilding and Dry Dock Company at Kearny, N. J.—solved a part of the rubber-shortage problem by using wooden tires on tractor-drawn trailers used for heavy-duty hauling. Each tire was made of 12 blocks of hard maple, sawed on a taper to fit in a circle against each other and the rim of a wheel. Before fitting, the blocks were soaked for 24 hours in linseed oil. The wooden tires are expected to last for one to two years. They replace 100-lb. solid-rubber tires.

AUTO Ideas

A METAL-SPRAYING GUN has been developed for building up and reclaiming worn auto, streetcar, train, and bus parts at low cost. Although of small size and weighing only 5 lbs., it can apply coatings as thick as 1", and can build soft steel into a sturdier, more durable metal. Wire is fed by a compressed-air turbine into the gun, where a high-temperature flame melts it so that it emerges in the form of a fine metallic spray.

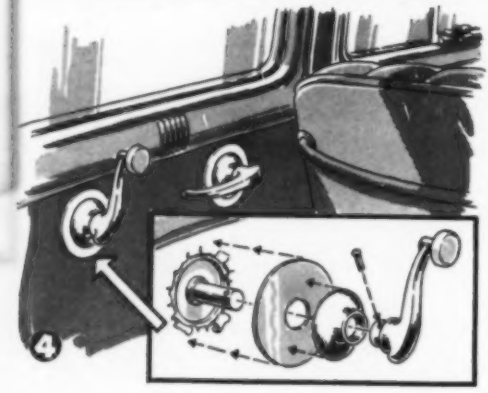
SPEED GOVERNOR. The easily installed device shown at the left, which fits on the accelerator of any car, acts as a constant check to keep one within the legal speed limit. It is set to the desired cruising speed—30 or 35 m.p.h.—and when this is reached, the base of the device comes in contact with the floor board, causing extra pressure to be exerted against the foot as a reminder that you have attained cruising speed. Unlike an ordinary governor, this handy guardian doesn't lock the speed. If full engine power is needed for climbing hills or for emergencies, extra foot pressure is exerted, and the accelerator goes down as far as desired. When the extra pressure is released, the mechanical "policeman" returns to its original position, and you can continue at the set speed. Anyone can install the device in a few minutes.

TIRE-THEFT PROTECTION—with a bang—can be had with an ordinary spring mousetrap, a beer-can opener, a few brads, a bit of wire, and a .22-caliber blank cartridge. The result is a resounding alarm that will frighten the would-be thief away or summon the neighbors. Slide the can opener under the spring of the trap so that the hole in the end overhangs, adjust it for the spring arm to strike a rim-fire blank cartridge inserted in the hole and held with chewing gum or a narrow strip of tape, and drive in several brads to hold the can opener firmly in place. Wire wound around the arm at the point of contact will add weight to the "hammer." Remove the hub cap of one wheel; place the trap, facing outward, in the wheel recess, and set it carefully. Then replace the hub cap. This usually frees the trigger, leaving the alarm ready to go off the next time the hub cap is removed. If it should go off with the hub cap in place, put a block under the trap so that it will press more closely against the cap.—J. T.



HINTS FOR CAR OWNERS

DRAWINGS BY STEWART ROUSE

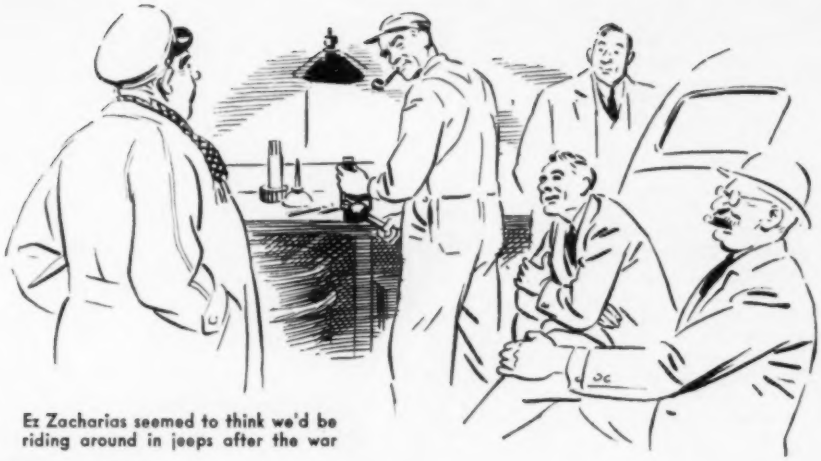


1 **A CLOTHESPIN** can be a great help in tire changing or repairing. Simply slip the pin over the valve stem after the latter has been pushed through the hole in the rim. This prevents the valve from slipping back inside while the tire is being mounted.—J. McC.

2 **CAR-TOP LOADS** are difficult to tie fast, especially on streamlined auto bodies that offer few projections to which ropes can be attached. One way to solve the problem is to catch four well-padded S-shaped hooks under the edges of the mudguards, placing them in the line of the most direct pull of the ropes. These are slipped through the hooks, crisscrossed over the load, and securely tied. They will not hinder the opening of car doors or the trunk. As many ropes as necessary can be used.—H.C.K.

3 **TIRE THIEVES, BEWARE!** The sign shown in the drawing above should serve as warning to would-be thieves. Attach the card to the sun visor in such a way that it will be facing outside when the visor is pulled down.—J.R.D.

4 **BADLY WORN UPHOLSTERY** around car door and window handles can be protected, and the appearance of the car improved, by cutting a disk of thin celluloid about ¼" larger in diameter than the handle flange, and placing it behind the flange as shown at the left. This shield will prevent further wearing of the upholstery.—J.F.L.



Ez Zacharias seemed to think we'd be riding around in jeeps after the war

GUS finds trouble in the air

By MARTIN BUNN

GUS WILSON'S shop isn't nearly so frequented a gathering place these days as it used to be. Since Pearl Harbor hardly anybody in our town has time to sit and talk. But once in a blue moon a half dozen Model Garage regulars drift in and the shop slowly fills with a rich mixture of tobacco smoke and conversation. Gus always keeps plugging away at whatever job he happens to be working on, but his wide grin shows how much he enjoys these brief "gab sessions."

One of these chance get-togethers took place last week. George Knowles, who is our chief air-raid warden, stopped in to buy a couple of flashlight batteries, and was soon joined by big Ez Zacharias, the R.F.D. carrier. On his heels came Doc Marvin, smiling and genial as always, though he was dog-tired after a long day at the hospital.

"This *is* like old times!" Gus told us all as he straightened up from Ez's disassembled carburetor.

We discussed the war at first, but the talk soon drifted to the changes it was likely to leave in its wake. That set us all to making predictions about what after-the-war automobiles would be like. George Knowles contended that they would look like streamlined planes, because he was sure that the day the shooting stopped some of the big aircraft companies would start shifting over to the production of cars of revolutionary design. Ez Zacharias snorted his disagreement, and said that we'd be driving around in second-hand jeeps.

Gus went on with his work as he listened without saying anything. Finally someone asked him what he thought about it.

"Well," he said, "I hardly think I'll be needing a new car for a spell."

He had hardly finished speaking when a bell jangled and Joe Clark came into the shop to tell Doc Marvin that he was wanted in his office. Doc grunted and got up.

"What I came in for," he told Gus, "was to ask you to take a look at a car I've got outside. It's an old-timer that belongs to my brother, who's a farmer upstate. His little girl has been having some trouble with her ears, and yesterday it became so bad that Fred and his wife brought her down to my office.

"They had a tough trip, for the child's right ear was getting more painful by the minute, and Fred couldn't get his car to do over thirty. The moment I examined the child I knew it was a case for a specialist. So I packed Fred, his wife, and their daughter in my car, and had them use it to drive down to the Medical Center in the city. There just wasn't any time to lose."

The Doc tugged at his chin. "This morning Fred phoned me the specialist had decided on an immediate operation. As a result, Fred and his wife are staying down at the Center, and I'm stuck with an old bus that wouldn't go half fast enough if I had to answer an emergency call. I don't know

"It's a queer thing, Doc," Gus said. "But when a fellow is trouble-shooting, the last thing he's likely to think of is the breathing parts of a car. Folks keep forgetting a car is like a human being in more ways than you'd suspect."

what's the matter with the car, but Fred says it hasn't been cutting up for more than 48 hours. I hate like the dickens to ask you to work overtime, Gus, but—"

Gus grinned at him. "I can't make any promises, Doc, but if it's anything I can fix tonight, you'll have it in the morning."

George Knowles had a call to make and offered to drop Doc and Dave Sledd at their houses, so the three of them drifted out. Gus reassembled Ez Zacharias' carburetor, and sent the R.F.D. man on his way. Then he went to the Park House for his dinner.

He got back to the shop about 8:30. Shifting into his working clothes, he lighted his pipe, and stood staring at Dr. Marvin's borrowed car with a puzzled expression.

After a few minutes of pondering he got in and stepped on the starter. The engine took off promptly, and ran smoothly enough considering its advanced years. What was even more gratifying, when he pressed his foot gently down on the accelerator pedal the engine speeded up. But — when he pressed harder, the engine suddenly slowed, missed, and coughed to a stop.

Gus scratched his head. "It might be the gas line," he muttered. He got out and checked the fuel pump and fuel line, but couldn't find anything wrong with either. Then he checked the spark plugs and their wiring, but found them also in perfect condition.

Although Gus did a little mild cussing then, he was really enjoying himself. There's nothing he likes better than a good trouble-shooting job. After another session of head scratching he removed the carburetor, dis-

assembled it, cleaned all its parts, and put it back. Then he opened the shop doors, and drove the car out for a road test.

Before he got as far as the road, a taxicab stopped at the curb, and Doc Marvin jumped out. "Hi, there, Gus!" he hailed. "Going for a joy ride? I'll come along with you."

He climbed in, and Gus drove slowly up the road. His eyes on the speedometer, he increased the car's speed in slow stages. Twenty . . . twenty-five . . . thirty . . . and the engine choked, sputtered, and stopped.

"I'll be damned!" Gus said with feeling.

Dr. Marvin laughed. "It's been acting that way for two days," he reminded Gus. "There must be a reason."

In grim silence Gus started the engine again, and drove back to the shop. They both got out. "This one has me away out on a limb!" Gus confessed with a wry grin.

The doctor nodded sympathetically. "It's a funny thing, Gus. For the last week I've had a hunch that something bothersome was going to happen, a sort of feeling of trouble in the air."

Gus stared and his mouth dropped open. "What was that you said?" he demanded. "Trouble in the air? Holy sufferin' cats! I *am* dumb!"

Two long strides took him to the car. Dr. Marvin watched him as he worked over the engine. Suddenly Gus closed down the hood. "Come on, Doc," he said. "Let's take another ride. This time we'll *move!*"

They got back into the car, and Gus drove it out of the shop. As soon as they were on the road, he increased speed. The speedometer began to climb. Twenty . . . thirty . . . forty . . . sixty!

"Holy smoke!" Gus exclaimed. "She's traveling like a bird now."

Back at the shop, Gus removed the air cleaner — it was of the oil-bath type, mounted on the side of the engine, with a rubber hose extending to the carburetor. The inside of the hose had weakened at one point, so that it curved slightly on its way to the carburetor. Every time the engine was accelerated the suction caused the hose to close gradually until, when the car was going about 30 miles on wide-open throttle, the hose closed up completely, shutting off the air supply to the engine.

"There's the cause of all the grief," Gus said, pointing to the hose.

"But what the dickens flattened out the hose?" Dr. Marvin gasped.

Gus poked a forefinger into a sticky mess on the filter screen. "Some time ago," he guessed, "your brother had his air cleaner checked. Whoever did the checking refilled the oil bath 'way above the proper level—and forgot to clean the screen. It was the carburetor suction that collapsed that hose . . . Make yourself comfortable, Doc, and in half an hour I'll have this old bus dancing the polka. I'll just clean out the filter and install a new hose."

Dr. Marvin beamed expansively. "Right," he said. "But there's one thing I still don't understand. You said you were stumped. Then all at once you knew what was the matter. How come?"

Gus laughed. "When a fellow is trouble-shooting, the last thing he's likely to think of is the air cleaner—in spite of the fact that for every gallon of gasoline you burn, just about 10,000 gallons of air have to pass through the cleaner. Well, Doc, I ran true to form and didn't think of that angle —and maybe I wouldn't have thought of it yet if you hadn't made that remark about 'trouble in the air'!"

Photography

In this series of one-shot exposures, Mr. Lester vividly portrays the life cycle of a silkworm.

ONE-SHOT PHOTOGRAPHY

PLANNED ECONOMY MAKES EVERY EXPOSURE COUNT

By HENRY M. LESTER
Editor of the *Photo-Lab-Index*

JOE is a professional photographer—an old-timer. He still uses glass plates in a huge view camera with a brass-mounted lens. I met him one afternoon, packing his paraphernalia. He told me that he was going to photograph a high-school graduating class. Then, suddenly, he remembered something.

"Jim!" he shouted. "Load me a plate!"

"*One* plate?" I remarked.

Joe looked puzzled.

"Why not?" he answered. "I'm going to take only one picture."

There is a lesson in this for the amateur—and the professional, too—who goes out for a day's shooting with 36 exposures in his camera and a pocketful of extra cartridges. That wasn't so bad in the prewar days of plenty when we could afford to shoot wildly in the hope of getting perhaps one salon print out of three dozen negatives, but today's need for economy brands it as waste.

Extra exposures are sometimes made because of lack of a definite idea or plan; more often they are in the nature of insurance. However, the professional's pictures almost always "come out," and there is no reason why yours shouldn't too.

Suppose you were told that for 1943 you could have only one dozen cut films or the equivalent in film pack, roll, or 35-mm. Could you be sure that at the end of 1943 you would have twelve pictures—good pictures—to show for it?

The professional has had years of experience, but you, too, can have the benefit of experience—if you are willing to take advantage of that incorporated in books, pamphlets, and even in the equipment and supplies you use.

You can start utilizing it the moment you open a box of film, paper, or developing powders. Nine times out of ten, a piece of paper then flutters to the floor. It's the *instruction sheet*, and it used to stay on the floor until it was swept up. The first step in making sure that all your pictures come out is to read this sheet.

It usually gives the speed of the film, which is information for use with an exposure meter, and a list of recommended exposures for various light conditions, which is valuable if you don't use a meter. There will also be a recommended developer, and instructions for its use.

Read the instruction sheet in every new box of film. Improvements are continually being made, and changes in exposure directions frequently result.

Now the next thing . . . what are you going to photograph? The days of making innumerable "tests" to see the effect of underexposure, overexposure, various filters, and the like, are over. Instead, you must plan your picture before you take it. If it's a landscape, visit the scene at different times of day, determine at what time the light falls from the desired angle, and be there then to take your picture. It is even well, if you can, to make a few sketches to decide on the best composition. It will save cropping on the enlarging easel by putting the final picture on the entire negative area instead of on a small section.

So—you know your picture; from the instruction sheet or meter you know your exposure; and you're ready to shoot. Be

SILKWORMS present a fascinating picture story in their life cycle of six weeks to two months, as shown in the accompanying 1/200-second synchronized-flash shots made for the Russell Sage Foundation at John Ousta's silk farm at Riverdale in New York City. The cocoon on the facing page is the final product of the larva, and consists of more than half a mile of pure silk, which is unwound after the pupa sleeping in it has been killed by suffocation with steam or hot air. In some cases, the silk moth is allowed to mature in order to lay the eggs needed for the propagation of the colony. The moth with outspread wings on the facing page is a female just after hatching. A male just out of the cocoon is shown on a following page. It is the worm, though, that gives us silk.

Eggs laid by the female silk moth are both the beginning and end of the life cycle—the start for the silkworms that are hatched out, as shown above, and the end for the moths, both male and female, which die shortly after the eggs are laid. Here some of the silkworms are shown emerging from their eggs to feed on mulberry leaves. They eat incessantly and grow at a great rate

sure to use a tripod.! Most blurred negatives come from camera movement. Focus carefully, set lens aperture and shutter speed. Now *stop* and *check!*

1. *Finder.* Is image composed as you want it?
2. *Focus.* Is the image sharp on ground glass or in range finder, or is the distance scale set right?
3. *Exposure.* Is the shutter speed adjusted as called for?
4. *Diaphragm.* Is the lens aperture correctly chosen, and the pointer set accordingly?

If all is ready, then—and then only—shoot. Then fold your camera, and go away without taking a second shot to "make sure." You won't need it.

The picture can, of course, be spoiled in developing. A developer can only bring out on the film what your exposure put on it. It *cannot* change the tone values; it can only change the relation between them—the contrast. This, however, is under control in printing, and the negative should always be developed the same way.

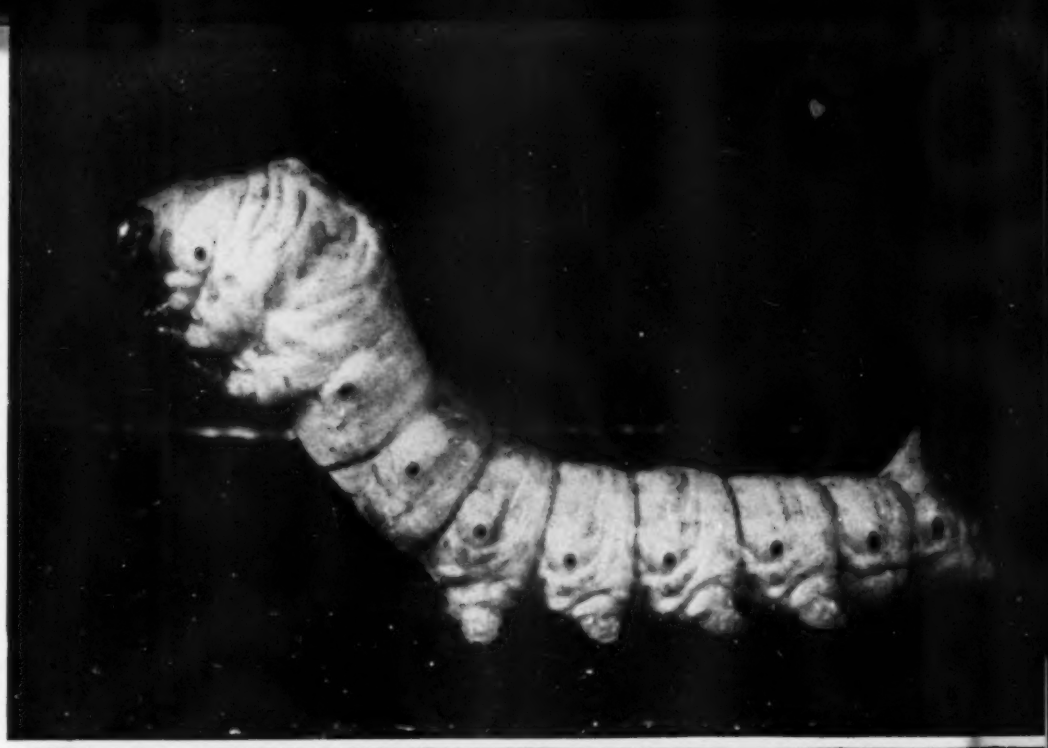
You need a thermometer and a package of the manufacturer's recommended developer—unless you mix your own, and you'll find the formula on the direction sheet if you want to do that.

Your developing instructions on the slip in the film box will tell you, perhaps, that correct developing time for this film is 15 minutes at 70 deg. F. You have then, two things to watch. First, the temperature of the developer. Hang your thermometer in the bottle. If it's over 70 deg., stand the bottle in a pan of cold water until the temperature drops to 70; if it's colder than that, warm it in a pan of warm water.

With the temperature at 70, we know it will take exactly 15 minutes to develop the film properly. We don't have to watch the film at all. But we do need a clock to tell us when 15 minutes are up. No guesswork!

When the time is up, the film is rinsed in plain water to stop developer action, then transferred to a fixing bath—recommended formula again!—and washed and dried.

Making prints is the same story. Read the direction sheet in the package. Cut up one sheet of paper for test strips—using a whole sheet for each test is wasteful. If



In the photo above, the silkworm is about ten days old and has attained a length of about an inch. With the forepart of its body raised, it has the appearance of a scaled, medieval dragon

When fully grown, as below, the silkworm spins a silken cocoon about itself in one continuous thread. The silk thread is made up of two fine filaments seriposited from two separate glands

Here two grown silkworms are hunting a spot on dried oak leaves for settling down to the task of preparing their cocoons. Sericulturists seek to keep them far enough apart to avoid tangling

Below is a male moth, somewhat smaller than its female counterpart. This moth, like the female on a preceding page, was caught with a one-shot exposure within a short time after being hatched

the direction sheet says develop 1½ minutes at 70 deg., expose a test strip and develop it 1½ minutes *without looking at it*. If it's too dark or too light then, you know what to do. If you develop it by watching, and pull it out of the developer when it "looks right," your test won't mean a thing.

Of course, if you use roll film, you can't develop each shot separately, but since your developing time and temperature are standard, you don't have to. If you follow the exposure directions carefully, an eight-exposure roll can have eight different pictures on it, and every one perfect!

The primary method of conservation, of course, is care in choosing subjects. Don't take a picture unless you know you really want it. If you own a cut-film camera, try going out for a day with *one* plate holder. When you have only one piece of film with you for a day's shooting, you don't snap aimlessly.

Printing, too, presents opportunities to conserve materials. Very few pictures require printing on an 11″ by 14″ sheet; only one in a hundred deserves a 14″ by 17″ or larger format. Stick to 8″ by 10″ and smaller sizes.

In a way, a limit on use of materials is a blessing. It can lead to fewer bad pictures and more good ones. If you have only one negative to expose, you can spend more time on it, and make it right. If you have only one negative to print in an evening, you can do much better than if you tackle the job of printing three rolls of 36 exposures each in one session. You'll probably have less time to spend on photography anyway. Make every minute, every piece of film, every sheet of paper count.

ELIMINATE UNWANTED DETAIL on your enlargements by using a crumpled cellulose wrapper from a pack of cigarettes as a diffusion filter. Whether your enlargements are made from 35-mm. films or larger negatives, such a filter will often help you to improve print tones, reduce excessive contrast, and soften hard lines, and yet retain all the fine detail you wish to preserve.

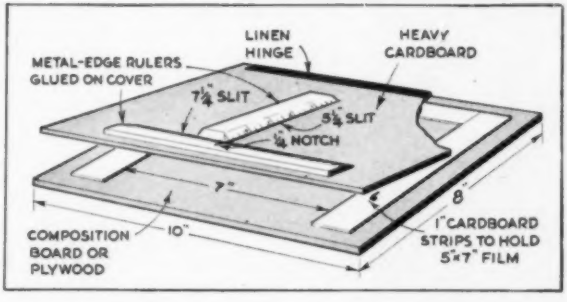
If the cellulose film is kept under the lens for about one third of the total printing time, the exposure will not be much longer than if no filter at all were used, and the resultant print will show no detectable loss of detail, but a great improvement in smoothness and tone, in many cases without grain. Keep the filter constantly in slow motion under the lens.

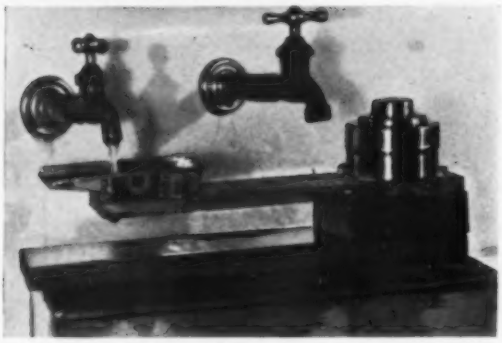
Portraits made on large negatives often show excessive detail and harshness, for a good camera lens sees far more detail than does the eye. Furthermore, seeing by light contrast rather than color contrast, it will bring out skin defects that are invisible to the eye. The photographs above are all reproduced from four-diameter enlargements made from part of a 9 by 12-cm. negative. The one at left is a straight projection print; the center print, which in this case required a little longer exposure, was made with a cellulose filter under the lens for about a third of the total exposure time, and the print at right was diffused for three fifths of the exposure. Skin markings are banished, tones are smoother, yet all desirable detail, even to the hairs in the eyebrows, is retained.

The same method can be used on landscapes to give atmospheric effects, turning strong summer sunlight into soft autumn haze. When making montages, a strip of crumpled cellulose film along the blend line will be found to render it practically unnoticeable.—JOHN W. CAMPBELL, JR.

A HOMEMADE SHEET-FILM CUTTER will enable you to save time and money by purchasing double-size film for your plate-back camera and cutting the film to size in your darkroom. All you need do is place a sheet in the three-sided frame, close the cover, and run a single-edged razor blade down and across in the slits, using the rulers as your guide. This will give you two 9 by 12-cm. sheets from a 5″ by 7″ film. To protect the razor edge and to prevent the bottom board from becoming grooved, a loose strip of cardboard may be placed under the film when it is being cut.

Although it is designed for users of 9 by 12-cm. film, the cutter can easily be adapted for other sizes as well. If you have waste film on two sides, simply cut another slit and mount a third ruler as required.—STEPHEN CAVELL.





Above, tank agitator ready for use. The tray fills with water until it is heavy enough to drop and lift the tank, falling to its original position as soon as the water spills from it

THIS HOMEMADE AGITATOR, suitable for any type of roll-film tank, works like a seesaw, with the tank at one end and a water tray at the other. A few small pieces of scrap lumber and a piece of tin cut from the side of a 2-qt. oil can are all you need to build it.

A block of wood 2" by 4" by 6" mounted on a baseboard will do for the fulcrum on which the movable board rests. Two small nails, placed near the edge of the fulcrum, fit inside corresponding screw eyes in the movable board to prevent it from creeping out of position when the agitator is in action. Four small blocks of wood hold the tank in place at one end of the board.

To find the correct position for the water tray, first fill the tank with water and place it on the board. It should be just far enough out to lift the fully loaded tank. When you find the position at which it operates most efficiently, fasten it to the board with small nails. Block the front up with a small piece of wood. It is advisable to coat the metal parts with waterproof paint or enamel, which will prevent them from rusting.—ROBERT SCOTT.

AMATEUR MOVIE FANS who would like to use the filters from their still cameras on their movie cameras can do so by a simple method involving very little labor and no cost. Simply enlarge the diameter of the movie-lens mount until it fits the larger filters. This is done by rolling a narrow band of light cardboard around the lens barrel, cementing it down as it is being rolled, until it is large enough to fit the filters neatly and snugly. This collar, shown in the photo at the left, can be left on the lens or removed when not in use. A further advantage is that such a collar arrangement will also permit the use of a still-camera lens shade for shooting pictures against the light.—L. HOCHMAN.

A NOVEL SYSTEM of measuring out photographic chemicals with "custom-built" weights is shown above. Such a method saves time, since all necessary information is printed on the boxes used as weights.

Using lead shot, pebbles, or some similar material, fill a small pillbox to the desired weight of each chemical required in the formula. Label the outside of each box with the name of the solution, the chemical it is to weigh, its weight, and the order-of-mixing number.—WM. SWALLOW.

EVEN ILLUMINATION, necessary when copying pictures or printed matter with a camera, is easily obtained by placing two or more silver-bowl lamps around the copy area, as shown in the photo above. The silvered globes direct light downward and also prevent direct rays from entering the camera lens. If each lamp socket is mounted on a block of wood, the lamps may be placed in any position quickly.—W. E. B.

TO KEEP A RECORD of film developer, showing how many times it has been used, paste a leaf from a small calendar on the bottle as shown below. Then, each time the developer is used, a number can be checked off. You will thus know when the developer has been used the prescribed number of times, and when to replenish it.

CURVED DRAWER HANDLES, such as are available for a few cents each, make it possible to move or adjust hot photoflood reflectors without waiting for them to cool. Two holes punched with a nail permit attachment of such a handle, and will not impair the efficiency of the reflector. The handles also help in carrying.—ANDREW M. LAVISH.

HOME AND WORKSHOP

Cardboard, wood, and a few pieces of celluloid substitute for hard-to-get metals in this toy plane. It's a homemade bomber that carries a highly accurate bombsight for blasting "enemy" ships in a thrill-packed war game

NAVAL BOMBING GAME

. . . . . Features Ingenious Bombsight

By MYRON FLEISHMAN
Toy and Game Designer

ENEMY fleet sighted! . . . On target! . . . Bombs away! . . . Here's a realistic naval bombing operation brought to your parlor floor in miniature, and a fascinating game that's bound to make a direct hit with everyone who plays—and anyone can. All the thrills of an actual aerial attack are present; the bomber "flies" over the formation of warships below, selects a carrier, battleship, or cruiser for blasting out of the sea, gets into position over it, and releases the bombs over the target.

The bomber is made almost entirely of wood and cardboard, painted olive drab, and decorated with insignia and representations of pilot's cabin, ailerons, elevators, gunner's turret, cannon, and so forth. The fuselage, wing, stabilizer, and rudder are cardboard, while the nose, tailpiece, motors, turret, wheel assemblies, and bombs are made of wood. The bombsight is an ingenious device consisting of a mirror, guide lines, and a miniature plumb bob. The only other materials needed in the construction are some small pieces of celluloid.

To make the fuselage, cut a 1⅜" o.d. cardboard mailing tube to a length of 7½". Cut out a 1" hole with its center ⅞" from one end, and glue a celluloid strip, on which the bombsight pattern is inked or painted, over this hole, securing it also with small screws and nuts. Punch a small hole in the precise center, and through this, thread a plumb line ¾" long with a small weight on its end. Cut a 7/16" by ⅞" opening for the bomb bay, measuring 1⅝" from this same end of the fuselage, as shown in the drawing. For the bomb rack, extend a ¼" wide slot on a direct line with the bombsight center to a length of 2½". To complete the fuselage, make the wing slots, as shown, and glue on the rear gun turret, which is shaped to fit the tube.

The nosepiece is made of wood, shaped as indicated, with a small mirror fastened to it at a 45-deg. angle. For the tail, a piece of wood of the same diameter as the fuselage is shaped to size and a ½" hole is bored through it for sighting. Slots are made to receive the vertical fin and stabilizers, which are cut from cardboard, and a hole is then bored diagonally in the bottom for the tail wheel.

Cut a 12" long wing from cardboard, insert it in the slot in the fuselage, and glue it in place. The twin motors are 1" in diameter, tapered to a length of 2",

"Enemy" warships are set up in the first area on the target board, as directed below, and five bombs dropped. Surviving ships are moved and bombing is repeated over the other areas

slotted for a snug fit on the wing, and bored diagonally underneath for the ⅜" dowel that supports the landing-gear assembly. Celluloid disks 2¼" in diameter are fastened to the motors to simulate spinning propellers.

The bombs are made from ⅜" dowel, grooved to hang in the bomb rack, while the bomb release is fashioned from ½" wood dowel, formed as to slide along the bomb-rack slot. This arrangement makes it a simple matter to release one bomb at a time.

Ships are of thin wood, with a ½" wood dowel as support. They are cut to the three shapes and sizes indicated, then painted battleship gray, and numbered as follows: cruisers, "3"; battleship, "2"; carrier, "1."

DIRECTIONS FOR PLAYING THE BOMBSIGHT GAME

1 The target board is placed on the floor or on a low table, and the "admiral" arranges his fleet in the area marked *A*.

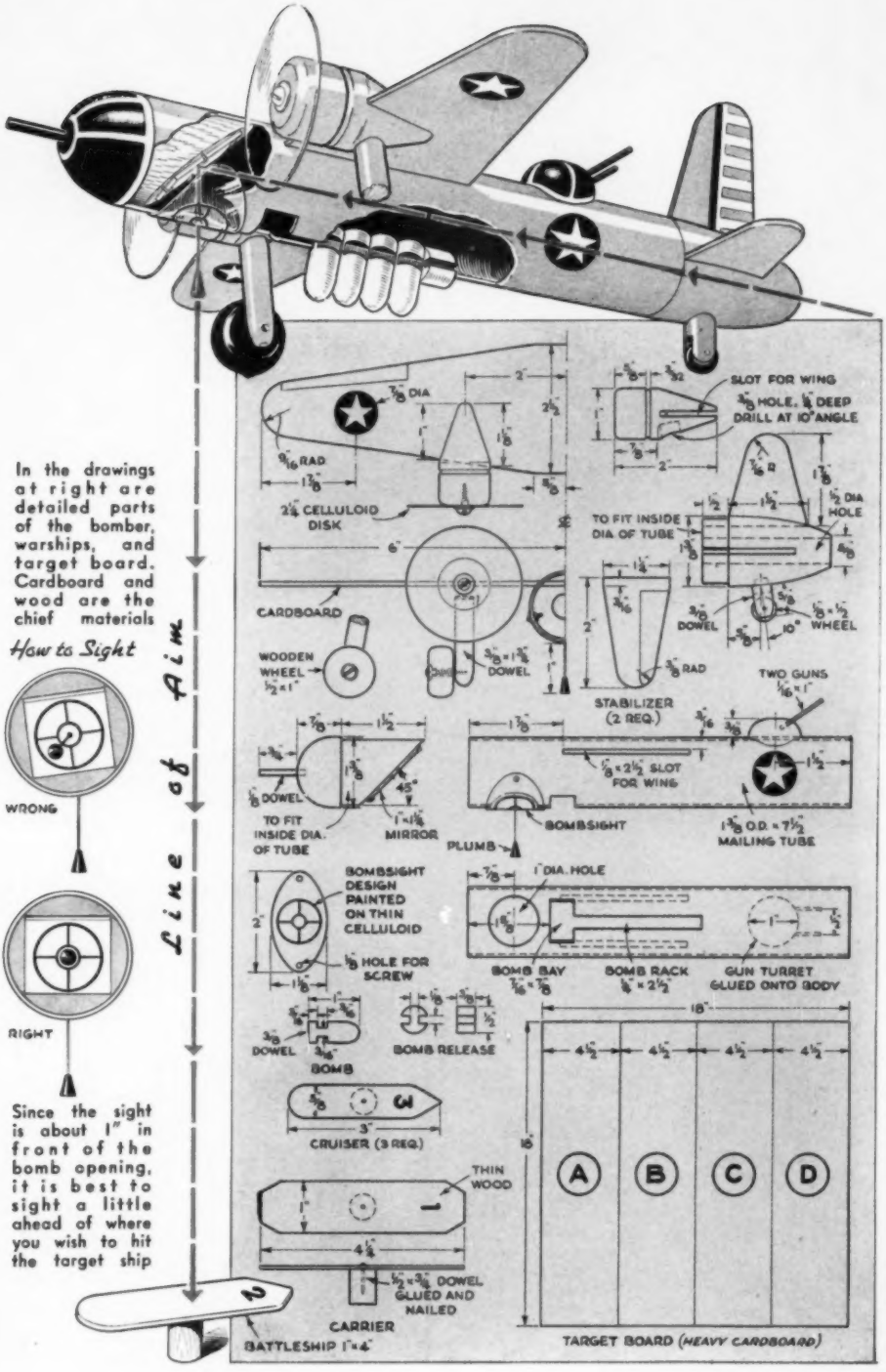
2 The "bombardier" loads his bomb rack, sights through the tail of the plane, and approaches the ships, holding the bomber on a level with his eyes. Both hands should grasp the wing, while one thumb should be ready to push the bomb release forward. When he sees a ship focused in the reflector, the player maneuvers his plane until the indicator is directly in the center of his bombsight. He then releases a bomb by sliding the trigger forward and, if his aim is true and his hand has been steady, the ship should be toppled on its side and "considered sunk."

3 When all five bombs have been dropped, the score for area *A* is tabulated. The number on the ship indicates its scoring value, to which four points are added for each ship sunk.

4 The "admiral" shifts his remaining warships into area *B*, and again the "bombardier" attacks. For the score in this area, three points are added to the value of each ship sunk, and the total is added to the previous score.

5 The action is repeated in areas *C* and *D* if any ships are left, with two points being added to ships turned over in *C* and only one point for ships sunk in *D*. The "bombardier" then takes command of the ships, the "admiral" flies the bomber, and when action is completed, contestants compare scores.

6 If no ships are left afloat after the bombing of area *A*, the "bombardier" receives the highest possible score, or a total of 32 points.


In the drawings at right are detailed parts of the bomber, warships, and target board. Cardboard and wood are the chief materials
How to Sight
WRONG
RIGHT
Line of Aim
Since the sight is about 1" in front of the bomb opening, it is best to sight a little ahead of where you wish to hit the target ship
BATTLESHIP 1"=4"
CARRIER
CRUISER (3 REQ.)
BOMB
BOMB RELEASE
BOMBSIGHT DESIGN PAINTED ON THIN CELLULOID
BOMBSIGHT
PLUMB
STABILIZER (2 REQ.)
CARDBOARD
WOODEN WHEEL
DOWEL
TO FIT INSIDE DIA. OF TUBE
MIRROR
SLOT FOR WING
TWO GUNS
MAILING TUBE
BOMB BAY
BOMB RACK
GUN TURRET GLUED ONTO BODY
THIN WOOD
TARGET BOARD (HEAVY CARDBOARD)
A
B
C
D

A busy housewife will find that the cabinet shown open above will often save her a tedious search for needed items when a sewing emergency arises in the household

The cabinet, which is of period design, blends utility and beauty to an exceptional degree. Closed (left) it will harmonize with almost any decorating scheme. Right, doors are built up with doweled frames

Period Cabinet

HOLDS ALL HOUSEHOLD SEWING MATERIALS AS WELL AS DRESS PATTERNS AND KNITTING SKEINS

By FRANK HEGEMEYER

A PIECE to gladden the heart of any homemaker, the Colonial cabinet shown at the left keeps in one neat, compact unit all the sewing materials and accessories found in the average household. It will harmonize with almost any type of room decoration. Standing 34¼" high, it is 20¾" wide and about 10" deep. The insides of the doors are fitted with racks to hold 40 spools of thread, while two scroll-sawed panels form racks for dress patterns and fashion magazines. Space is also provided for shears, thimbles, needle booklets, and so forth.

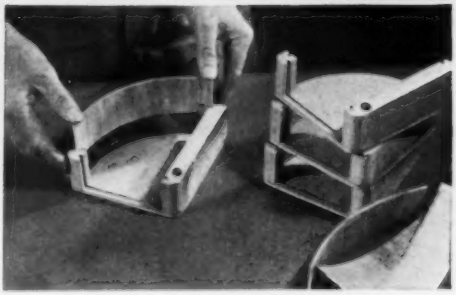
Perhaps the most interesting feature of the cabinet is the quadrant-shaped drawers, which swing out for ready accessibility. These have glass fronts for the user's convenience in identifying their contents quickly, and may be easily removed in case it is necessary to empty them completely or to replace the glass. The center bin also swings out and can be used for storing articles to be mended, while the handsome cabinet-width drawers provide ample accommodation for a great many other items.

Maple is an excellent wood to use in building this piece, but any other fine cabinet wood will serve equally well. Birch is a good choice if the cost must be kept down. The best figured stock should be used for the doors, top, sides, and base, in that order of preference. The remaining stock can be used for the drawer and bin fronts. Both door fronts are single panels, with 2" wide hinge pieces doweled to them at right angles. They are equipped with ball-type friction catches at the top.

Dado the two sides of the cabinet for the rails, which are glued and doweled in. Cut a ¼" by ⅜" rabbet in each sidepiece for the back. Both the top and the baseboard are joined to the sides with ⅜" dowels. The base has mitered joints with maple splines and is fastened to the baseboard with screws. The lower three-compartment bin is fastened

The hole for the pivot pin has been bored in the upper rail. Because of its length the pin must be permanently inserted before the top is doweled on

Stop block in vise aids in cutting glass fronts for the button boxes. The curved parts (below) can be made from thin veneer or a discarded radio cabinet

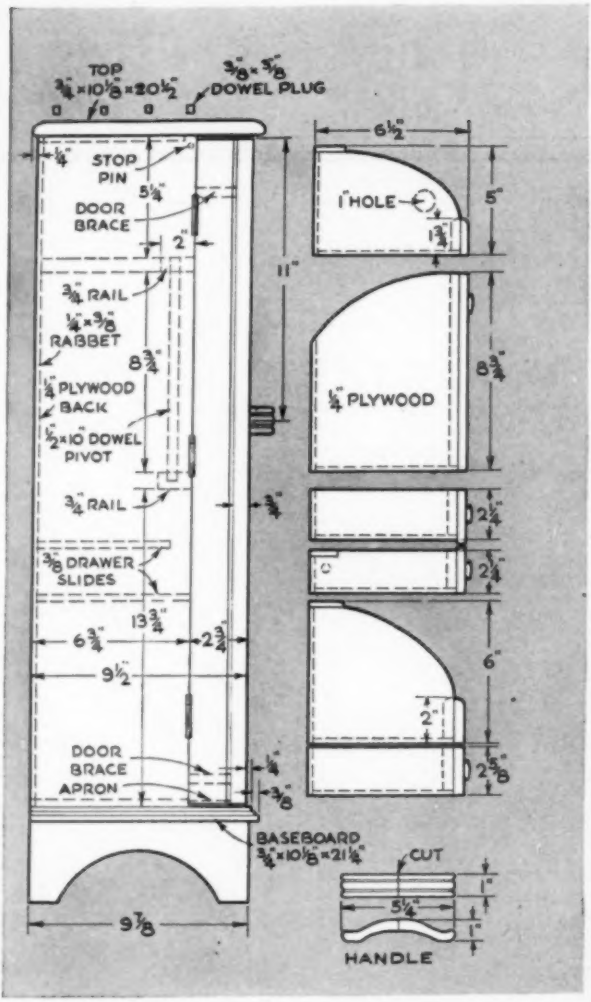


in place, but the upper yarn bin is free to slide out. A short piece of ¼" dowel is fitted loosely in the sides to act as a stop for this bin. The bin fronts are grooved for the partitions.

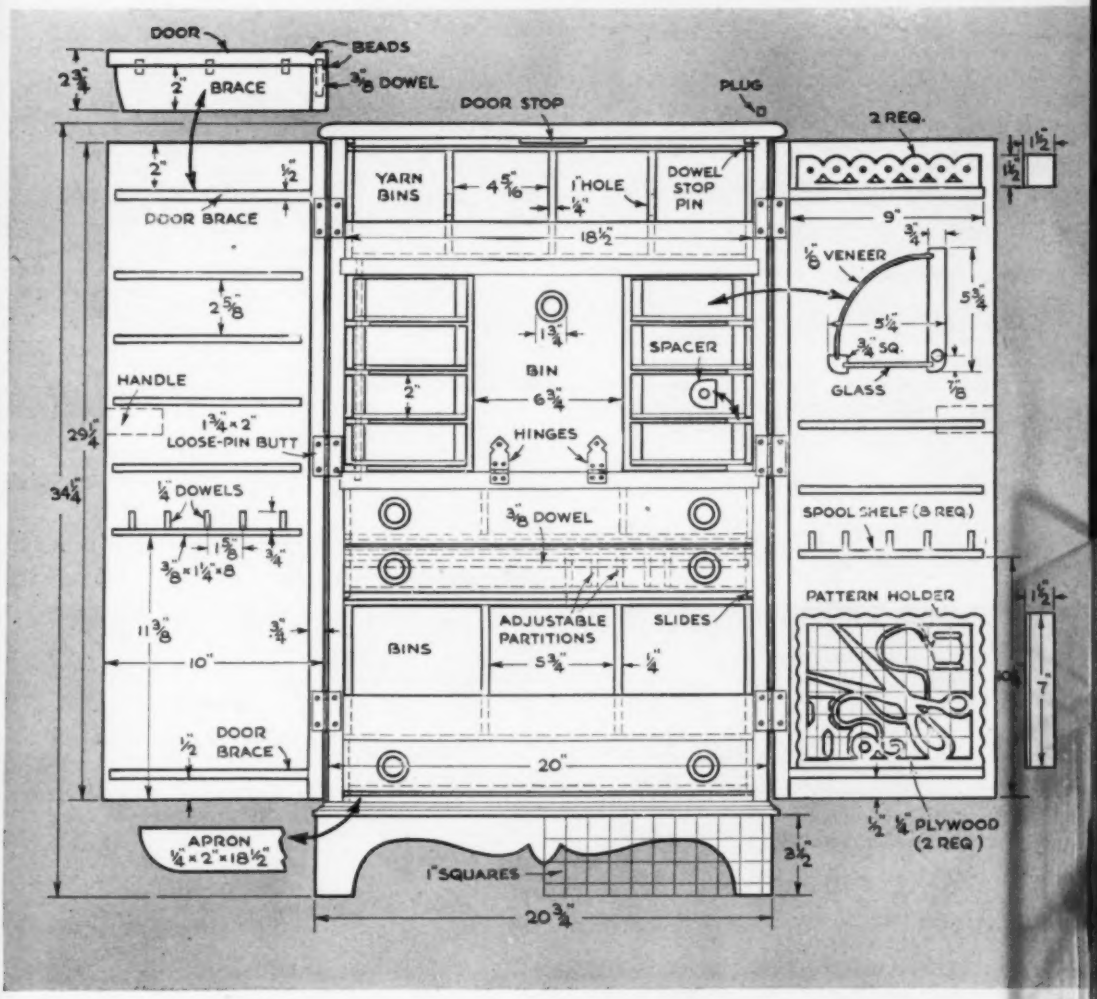
Underneath the lower drawer is an apron. This is glued to the baseboard and serves as a door stop. The doors are hinged with three pairs of loose-pin butts. To relieve their otherwise plain corners, run beads along the fronts and sides ¾" from the edge. Both door handles are made as one piece and cut apart later. Attach them with screws.

The parts for the eight button boxes can be cut eight at a time with the exception of the bottoms. The only difference is in the grooves for the glass, which are reversed in four of the bottoms. Corner posts are cut from a quarter-round strip which has been grooved on the two flat sides. The boxes are opened by pressing sideways on the pivot edges with the thumb.

Each button box has under it a shim or spacer ⅛" thick. This is placed on the dowel pivot with the flat edge against the side of the cabinet. A hole is drilled through the upper rail for the pivot pin. Because of its length



Below, a useful jig for cutting miters and spline grooves in the base parts. This jig is held against the head of the miter gauge



the pin must be inserted and brought to rest in the blind hole in the lower rail before the top of the cabinet is doweled on. The vertical strip shown inside the back in one photograph on page HW 69 acts as a stop to align the button boxes when they are closed.

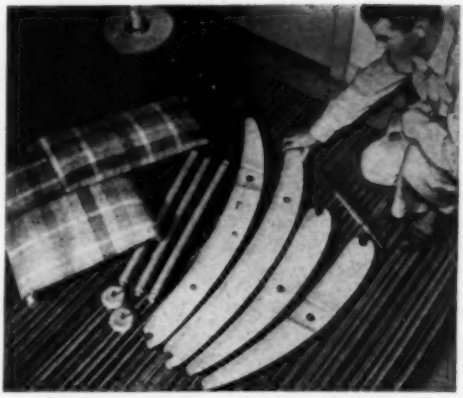
The lips of the extra deep drawer fronts will conceal the two drawer slides between. It is advisable to build the drawers slightly undersize so that they will move freely. All drawer and bin fronts have ¼" by ⅜" rabbets on the ends and bottom; all floors and backs are made of ¼" plywood.

The recessed drawer pulls are made by boring a 1¾" hole ⅜" deep with an expansive bit and fastening the knob inside it with screws. Be sure the knobs on the lower drawer clear the door brace and that all the spool shelves are doweled to the doors.

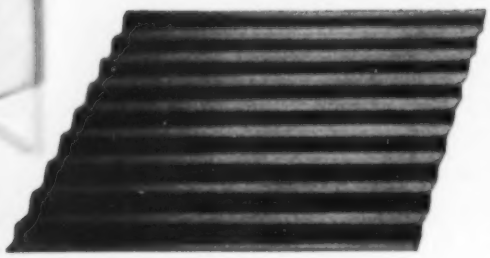
If the cabinet is made of maple or birch, it is advisable to procure a maple stain of the penetrating type. This stain will give the attractive mellowed finish which is characteristic of this type of furniture. If it is desired to highlight the wood for an aged effect, let the stain set about ten minutes and rub it off lightly with a soft cloth.

The photo at the left shows adjustable partitions in one of the drawers. These form compartments of various widths and are kept in contact with the bottom of the drawer by a narrow strip at the back

IDEAS for HOME OWNERS



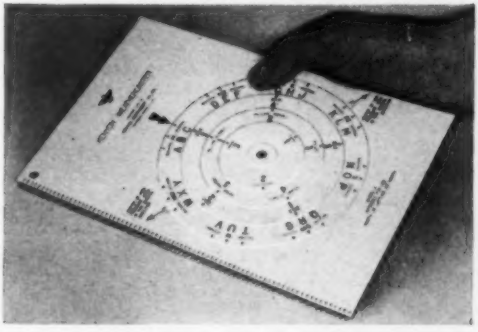
FURNITURE PACKED IN CARTONS. Tables, chairs, beds, even cradles, come packed flat in pieces that are easily assembled into modern, livable furniture. The parts are grooved so that they can be put together with two or three screws. Cupboards and chests come already assembled. Extremely light, this new furniture is made of limed oak or lacquered veneer on plywood. The only metal parts used are screws. Flexible wood replaces metal bedsprings. At right above are the parts of a chair. Directly at the right a small table is being assembled. Below is a living room straight from cartons.



CORRUGATED ASPHALT SIDING, rigid, lightweight, and waterproof, has been designed for wartime application on industrial, commercial and farm buildings as a substitute for corrugated steel sheets. The new product, shown at left, consists of two sheets of heavy felt saturated with a resino-bituminous compound, bound together with asphalt adhesive and corrugated under high pressure. The finished sheets retain their stiffness in summer weather because of the high melting point of the resins used.

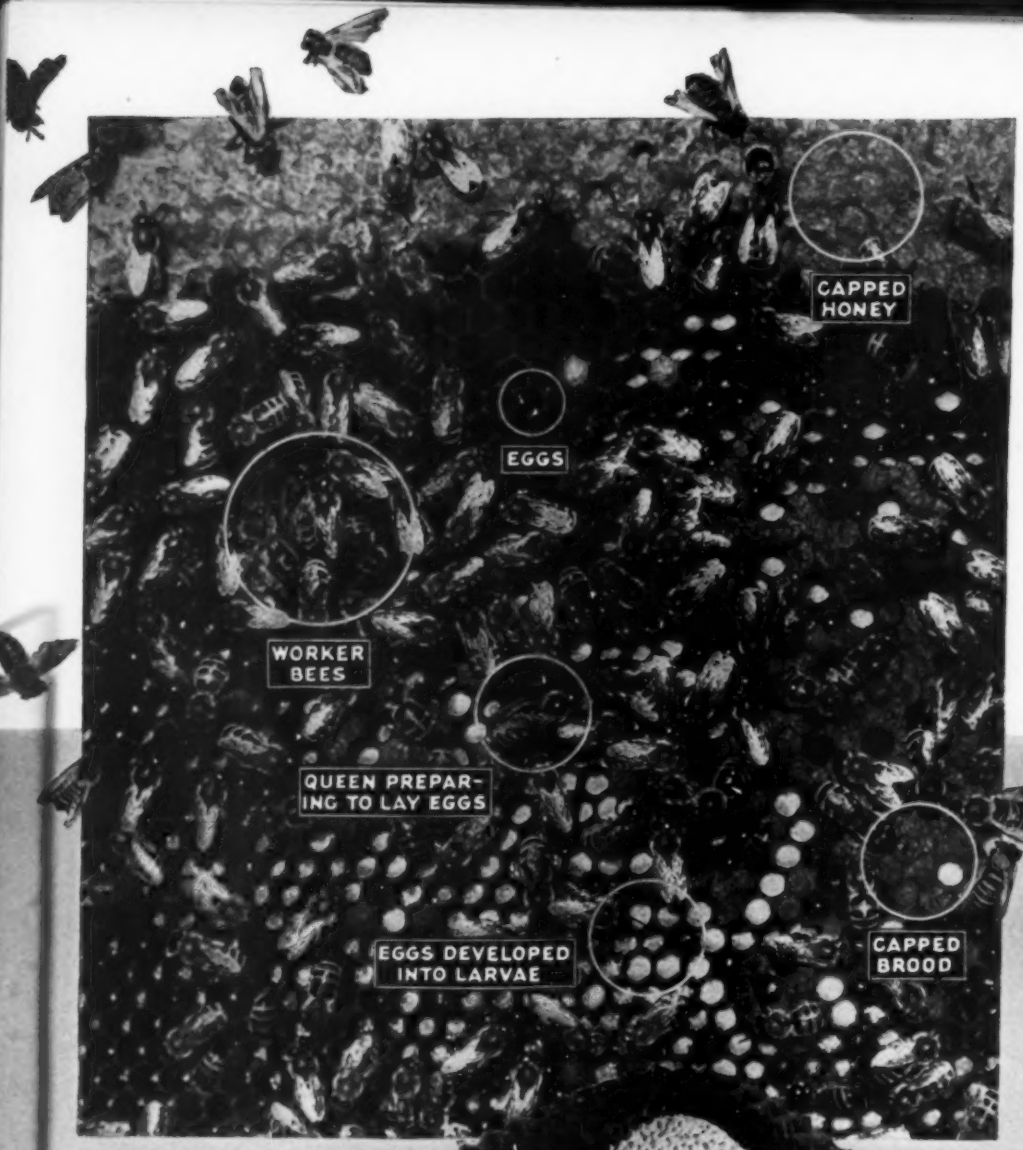
NEW FIREPLACE GRATES. The sectional ceramic grate shown directly above will stand any reasonable thermal shock, since each grate is fired for fourteen days up to 2,280 deg. When the grate has cooled, it is easy to separate the sections and clean them with a soft brush. Good combustion is produced with a minimum of smoke, since air is preheated, before entering the fuel bed, by passing first over the hot section. The latticed moss-colored grate at the right above is made of ground bottle glass, pressed until it has acquired the strength of cast iron. This grate has been tested to withstand 2,750 deg. without cracking and is said to burn coal, charcoal, and coke with equal efficiency. Both grates must be handled with care when they are out of the fireplace.

THE FIRE EXTINGUISHER shown at the left also serves as a decontaminator for three major war gases. The ever ready, free-flowing chemical contained in the extinguisher will not harm fabrics or machinery, and it is adapted for use in the home, office, or factory. The tubelike container is held in a horizontal position, and the fire is dusted with a sweeping left to right motion from edge to center.

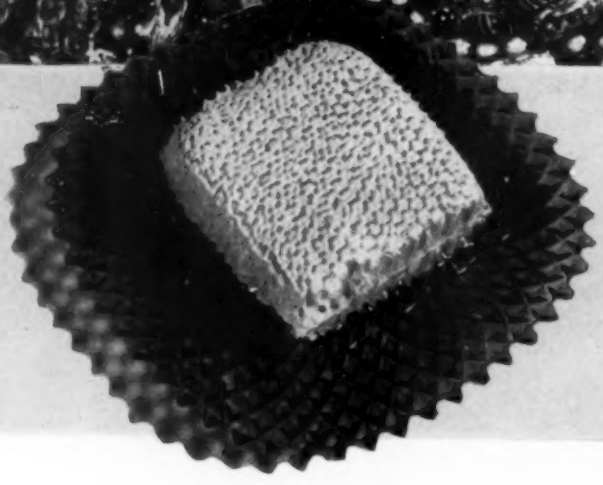


A DIAL-TYPE FORECASTER that, with the aid of a barometer, will make reasonably accurate weather predictions from 12 to 24 hours in advance, is shown above. Four concentric dials are set according to wind direction, barometer reading, barometer change, and present weather conditions. As the dials are set, numerals align themselves underneath the large arrow at the top of the forecaster. These numerals, along with their corresponding letters, are translated into probable weather conditions by referring to tables in the back of the booklet.

GLASS MAIL BOXES may replace tin and other metal types. The supports and the strip at the top for holding newspapers are the only metal parts. The heavy glass is strong and durable; it will withstand all kinds of weather and will harmonize with any background.



Cross section of a bee colony with a brooding queen and her faithful attendants. So great is her fertility that a hive may contain thousands of eggs and as many as 80,000 workers. Note snow-white caps on cells full of ripening honey



Comb honey, ready to eat as it comes from the hive, is a grand addition to any menu

Beekeeping—

How to Start a Hive for Honey Production in Your Own Back Yard

ANYONE looking for an interesting and productive outdoor hobby might well consider beekeeping. Honey is a natural, wholesome sweet that may profitably be substituted for war-rationed sugar in many instances—as a spread for bread, in candy making, in baking and cooking, and for use in beverages. You'll have no trouble giving away or even selling any surplus. The investment required is small—it is possible to start with one or two hives, set up in a corner of the back yard or the roof top.

But that is only half the story. Few hobbies are so inherently fascinating. You will find it a real thrill to open a hive and see the busy, purposeful life of the bees going on before your eyes.

Many people are timid about working with bees, but by observing a few common-sense precautions even the novice should have no trouble.

The first step is to assemble the hive. It is possible to build your own, but the beginner will find it easier to buy a hive. Full directions for assembling the accurately made parts usually come with the hive. It is wise to give it two or three coats of outside-white paint. The frames too must be fitted together and the wax foundations then inserted.

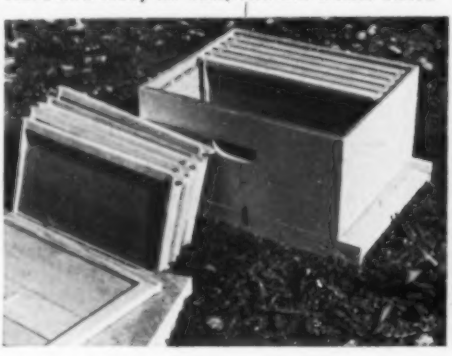
Now you are ready to supply your little factory with workers. You can do so by catching a swarm of bees, but unless you have had previous experience in beekeeping, this is rather unwise. It is best to order package bees. Caucasian bees are bred for gentleness, as are Italian bees. A common size is a 2-lb. package. You ought to have the bees delivered at the beginning of the fruit-blooming season so that they can get the full benefit of the blossoms.

Bees are shipped in a screen cage with the queen confined in a smaller cage suspended in the center. They are supplied with a can of sugar sirup on which they feed. Upon arrival, the caged bees should be taken to a cool place, where, at intervals during the day, they should be sprinkled with sugar sirup and allowed to gorge themselves. Sugar sirup can be made by mixing equal parts of sugar and warm water. Sugar for feeding bees may be

The beekeeper at the right is removing a bee-laden frame for examination. Smoke from the device at the lower right is blown into the hive to confuse the bees temporarily, so that they may be safely handled. It is always a thrill to open a hive and study its teeming activities

Hives come ready to assemble. When put together according to instructions, the parts will be found to fit accurately. The frames must also be assembled, and supplied with wax foundations. Lower photo shows hive ready for bees, with five frames added

Sugar sirup is sprinkled over the cage of package bees before it is put in the hive. A bottle with a clothes sprinkler is being used here. In the lower photograph the beekeeper is placing the bees in their future home, where they will begin their work



obtained by applying to your rationing board.

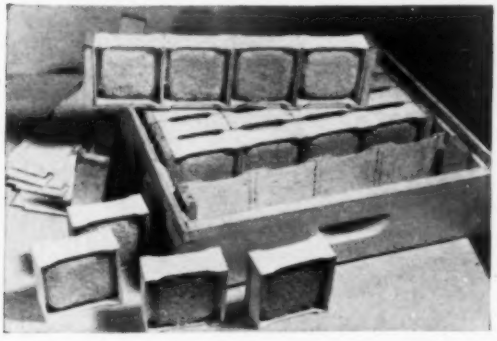
Toward evening the package should be taken to the hive, which should be permanently installed in a sunny spot facing south or southeast. Remove half the frames from the hive and insert the cage in this space. Pry off the wooden cover of the cage and remove the feeding can. The queen cage is taken out next, the small cardboard strip at one end removed, and a match pushed through the candy at the end of the cage. The bees will eat their way through this opening, releasing the queen in a day or two. The queen's cage is laid in the position shown in the photo. If the bees have had plenty of sirup, they will remain docile while all this is done.

Perforate the lid of a gallon pail of sugar sirup and invert this over the frames. Next, place an empty hive body over the frames and cover the top. Turn the entrance cleat to its smallest opening and leave the bees completely alone for a week.

By then the bees should have drawn out some of the wax foundation into the cells, and the queen should have begun to lay. If she has, your colony is successfully established. Those combs removed at the installation of the bee package are now replaced, and the bees left to their own devices for another week, at which time the sirup in the pail should be replenished. The colony should build up and draw out the wax foundation by the time nectar-bearing plants bloom.

The next step in producing honey is to

The beekeeper has placed an inverted pail of sirup on the frames, and above is covering the hive. Note how bees are swarming out to devour the sirup and free the queen, imprisoned in the small box on top. Below, section comb honey, choice of most beginners



When handling bees, beginners should wear a veil of fine netting slipped over a wide-brimmed hat and be armed with a smoker and hive tool. This beekeeper has taken all necessary precautions, but timid souls can wear gloves for added protection

add a previously prepared super (the removable upper story of a beehive) in which the bees can store their surplus. Several supers should be prepared, so that when space in one is almost filled, another may be added.

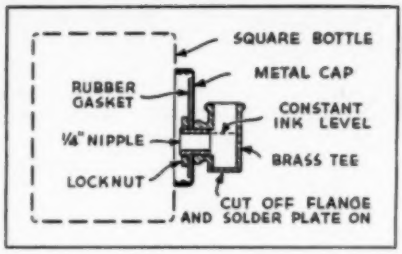
Beginners will find it easiest to produce section comb honey, as it requires no special handling, being served in the comb as it comes from the hive. For extracted honey to be put up in bottles or jars, larger combs are used. A machine is needed to extract the honey by centrifugal force, after which the empty combs are put back in the hive. They are used year after year.

The beekeeper should wear a bee veil of fine net slipped over a wide-brimmed hat as a protection to the face. A bee smoker is also necessary to keep bees under control.

The common practice in the colder sections of the United States is to destroy all of the bees in the fall and buy new ones in the spring. When this practice is adopted, the bees get a new young queen each year. There is also a saving in honey, for if the bees are kept through the winter, a considerable amount is consumed.

Some beekeepers prefer to keep their swarms through the cold weather, and if the bees have plenty of stores and a good windbreak they will as a rule come through in good condition. Information on wintering and other matters of interest to the beginner will be found in the many excellent textbooks and Government bulletins on the subject.—BENJAMIN NIELSEN.

Ink Maintained at Constant Level in Draftsman's Bottle

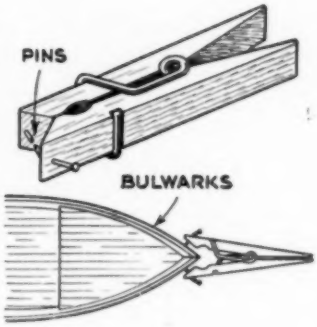


The drawing above shows the bottle in cross section. At the left is the completed inkwell. It will hold an extra large quantity of ink

UTILIZING the familiar principle of the inverted water jar, this cleverly constructed inkwell will provide the tracer with an abundant supply of ink, maintained at a constant level. Bore a hole large enough to take a ¼" brass nipple in the top and near one edge of the metal screw cap of a square ink bottle. Secure the pipe nipple with a locknut, using a rubber gasket on the inside to prevent leakage. Fit a standard-size brass tee to the nipple and cut off the flange on the bottom of the tee. Solder on a plate to close this. Cap the receptacle thus formed with a quill-cork from an ordinary India-ink bottle, and turn the dispenser on its side for use.—R. L. WHITMAN.

Spring Clothespin Aids in Gluing Ship-Model Bulwarks

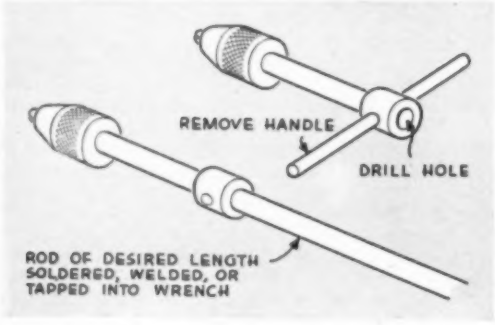
BULWARKS at the stem of a ship model can be clamped together with an ordinary spring-type wooden clothespin while glue is setting. Pins are inserted through the jaws, as illustrated in the drawing at the right, in order to hold the bulwarks against the curved surface of the bow.—WILLIAM S. LEIBBRANDT.



Homemade Hand Soap Removes Grime

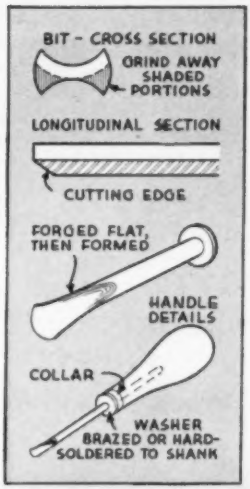
GREASY, grimy hands are no novelty these days. The problem of keeping them clean can be easily and inexpensively solved by making a soap solvent at home. Simply dissolve 1 lb. of soap chips in 1 gal. of boiling water. Remove this mixture from the fire, add ½ lb. of soda ash, 1 lb. of pumice stone powder, and ¼ oz. of oil of citronella. This solvent is harmless to the hands, and does an efficient job.—P. A. B.

Tap Wrench and Length of Rod Form Handy Drill Extension

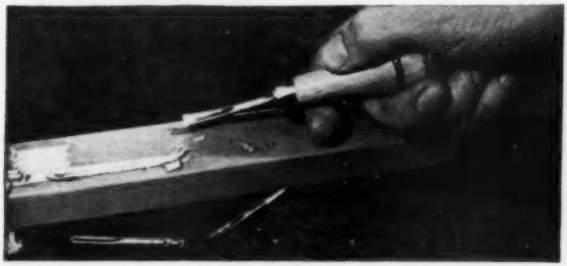


A DIME-STORE tap wrench and a length of welding rod, drill rod, or similar stock 3/16" or ¼" in diameter will make a convenient extension for use in an electric or hand drill. Remove the handle and drill a hole of suitable size down the center from the top. Insert the rod and weld or solder the joint. If you wish to use interchangeable lengths of rod, tap the hole and thread the rods for screwing into the wrench. Should the chuck prove too loose for holding small drills, file the slots slightly wider.—NORMAN F. WILLARD.

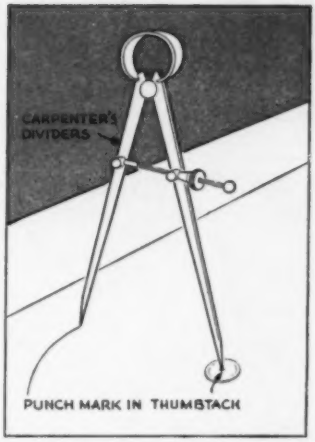
Old Drill Bits Are Easily Converted into Useful Woodworking Gouges



OLD straight-fluted drill bits can be converted into serviceable gouges. A simple method is to square the end of the bit, grind the sharp ridges to a C-shaped cross section, and sharpen the end to a cutting edge. Still another method is to heat the bits red, cooling them slowly, then reheating and forging the end to form a carving tool of the desired shape. Harden the gouge by heating it red and plunging it quickly into water. Polish the metal with an abrasive cloth; then temper by heating the end to a straw color, and again quenching.—W. E. B.



The gouge in use above was made from a drill of the type shown



Tack Forms Pivot Point for Scribing Materials

IN MARKING soft, flexible materials with large dividers, it is very necessary to maintain a steady pivot point. To avoid wobbling or inaccuracy, make a small prick mark in the head of a thumbtack and shorten the point with nippers or a file so that it can be used on thin substances, such as asbestos or rubber sheeting. The dividers will then have a true center, and the circles scribed will meet at their starting points.—H. D. CHAPMAN.

CONVERSION FACTORS [CALCULATIONS]

The following table lists conversion factors useful in electrical calculations:

To Change	To	Multiply by
Circular Mils	Square Mils	.7854
" "	" Centimeters	.000005067
" "	" Inches	.0000007854
Centimeters	Inches	.3937
Square Centimeters	Square Inches	.155
Cubic "	Cubic "	.061023
Kilowatt-Hours	British Thermal Units	3415.
Kilowatts	Horsepower	1.341
Deg. Centigrade	Deg. Fahrenheit	(1.8 x Deg. C) +32

To Change	To	Multiply by
Square Mils	Circular Mils	1.27324
" Centimeters	" "	197352.
" Inches	" "	1273240.
Inches	Centimeters	2.54
Square Inches	Square Centimeters	6.452
Cubic "	Cubic "	16.387
British Thermal Units	Kilowatt-Hours	.0002928
Horsepower	Kilowatts	.7457
Deg. Fahrenheit	Deg. Centigrade	(Deg. F−32)÷1.8

POPULAR SCIENCE MONTHLY SHOP DATA

When a latch, like that at the left, sticks flush with the lock face, the spring is faulty and must be replaced. Remove knobs, spindle, and screws to pry the lock out of the door with a screw driver

Repairing

. . . AND HOW TO FILE KEYS THAT WILL FIT THEM

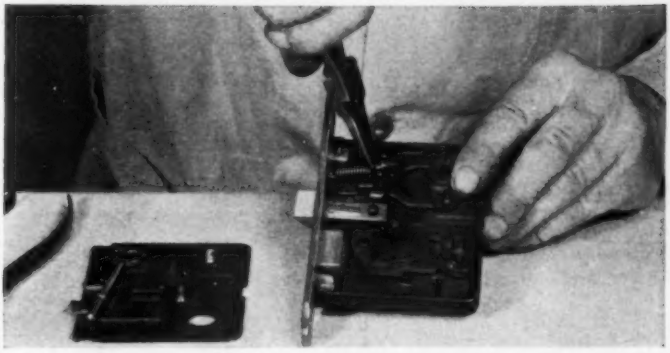
• • •

CYLINDER or pin-tumbler locks are now most commonly used as the safest for outside doors, but for every two of these in the average home, a half dozen or more of the older-type mortise locks will be found. These are the locks on the inside room doors, serving as latches even where the greater privacy of a lock is not required. It is these mortise locks, too, that are most often in need of repair, if for no other reason than that they are in almost constant use. Frequently the necessary servicing is a matter of simple adjustment or replacement of a part.

Take, for example, a door that will not stay latched when closed. This can be a nuisance, and the cause is usually a broken latch spring. The lock in the photograph at left is a case of this kind. The latch is back flush with the lock face, and there is no spring tension to force it out.

The first step is to remove the screw from

Take off the cover, and remove the broken spring, shown in the top left-hand corner of the lock at right



Insert a new spring, fitting it in with small-nosed pliers. Clean the lock; then oil and reassemble it

Ordinary Inside Door Locks

one knob, and either unscrew or pull off the knob. The other knob can then be pulled out from the other side with the spindle attached. Then remove the two wood screws holding the lock in the edge of the door, and pry the lock out with a screw driver.

Removing the lock cover reveals that a broken coil spring, shown in the photo at the top of this page, is causing the trouble. A new one from a hardware store or locksmith's shop is then installed with a pair of small-nosed pliers. Dirt in the lock is cleaned out, and a few drops of oil are applied to each working part.

This is a three-lever lock. The narrow flat springs attached to each lever should be inspected at this time, and broken ones replaced with some of the same spring stock. Drive out the broken piece from the side of the lever by using a thin piece of steel and a hammer. After breaking off a piece of stock to the approximate length, lay one end in the narrow slot in the lever and drive it in place. If it fits too loosely, a slight bend at the extreme end will cause it to bind when driven in. The new spring is then curved to the right shape, and the lever replaced on its spindle with the spring end pulled down to rest against its stop.

After replacing the cover, put the lock back in the door mortise, reversing the steps taken in removing it. Do not make the knob adjustment too tight, as this will cause binding. With square, straight spindles, washers should be used if necessary to get this adjustment just right.

Lock construction varies widely with different makes and ages. Some manufacturers use coil springs, others flat ones, and some a combination of both. To repair a lock that has a broken flat spring, use the same gauge stock, breaking it off to the length of the two pieces of the old spring. One end is then bent so it will lock between the two projections cast on the inside of the case. The free end should have a good upward tension and bear against the part shown in the illustrations on page HW82. Try it in place with a pair of small-nosed pliers. It may be necessary to alter the shape to get the tension just right.

In making a key for a mortise lock, select a blank that will not require much filing to fit in the keyhole. Its barrel should

When replacing a broken flat spring, use the same gauge stock and measure it to the length of the broken pieces. Bend one end to lock it between the cast projections inside the case

There should be good upward tension at the free end for the spring to bear against the pivoted part shown above. Try the spring in place, and reshape, if necessary, to get the tension right

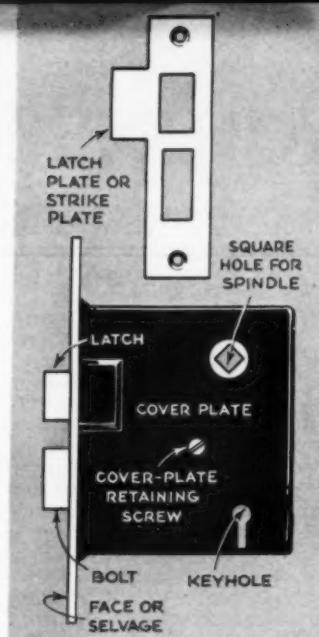
be a reasonably good fit for the round hole. The drawings on the facing page show a typical one-lever lock, a key filed for it, and also a key filed for a three-lever lock. After filing to allow the blank to enter the keyhole, hold it down with the shoulder against the case to determine the filing necessary for the width of the bit to fit inside the lock. In turning, the key will probably come against stops cast on the inside of the cover. Rocking it back and forth will make bright marks on the bit, indicating where to file a ward to clear. A ward should also be filed at a corresponding point at the other end of the bit to allow the key to be used from both sides of the lock.

The key will now turn further in the lock until it strikes the lever. Marks can be obtained the same way on the bottom edge of the bit to indicate the position of the lever and where the lever ward must be filed. A beginner may like to check on this point with the cover off, but it is better practice to make the key from marks.

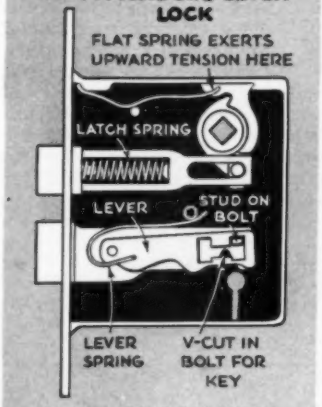
It may be necessary to round the end of the bit slightly to allow it to pass smoothly in the V-cut in the bolt. When the work is correct, the lever will be lifted so that the square stud attached to the bolt will pass through a narrow slot in the center of the lever and permit the bolt to be thrown out with the key. The lever ward should be filed by careful stages to keep it from getting too deep. Make frequent trials in the lock, and observe bright marks that will indicate where further filing is necessary. All sharp edges should be rounded off slightly.

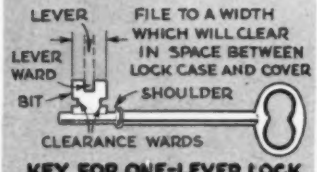
Making keys for three-lever locks is similar, except that three levers must be lifted varying distances until their center slots are in line, as shown in the bottom drawing, so the bolt can pass out. Levers are indicated by dotted lines in the drawing to illustrate how the wards are used on the levers when the key is inserted from opposite sides of the lock. The lock for this key has a projection on one side of the keyhole instead of stops on the inside of the cover, and a groove is filed across one side of the bit to clear this.

Sometimes it is not the fault of the lock when a door refuses to latch. A latch plate or strike with a worn band may show that the latch hits it too low to enter its opening. Tightening the screws of the top hinge may raise the door enough to remedy this condition. Otherwise, the strike will have to be lowered or a longer opening filed. If the cause is a warped door, move the strike out until the latch catches. Sometimes a door will shrink in width so much that the latch will not touch the strike at all, in which case a strip may be nailed along one edge of the door to increase its width. As a rule, this involves some refitting of the lock or hinges, and it may be easier to build out the strike with some thin wood placed back of it.—HAROLD P. STRAND.

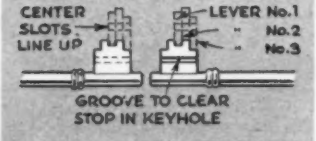


TYPICAL ONE-LEVER LOCK

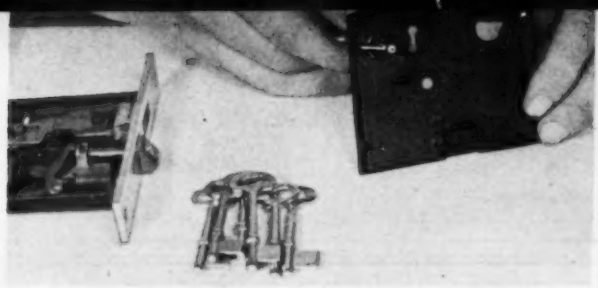




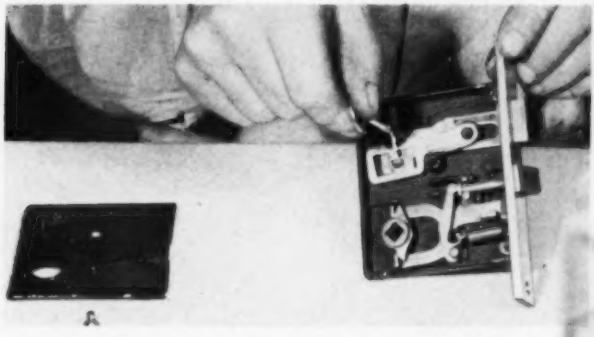
KEY FOR ONE-LEVER LOCK



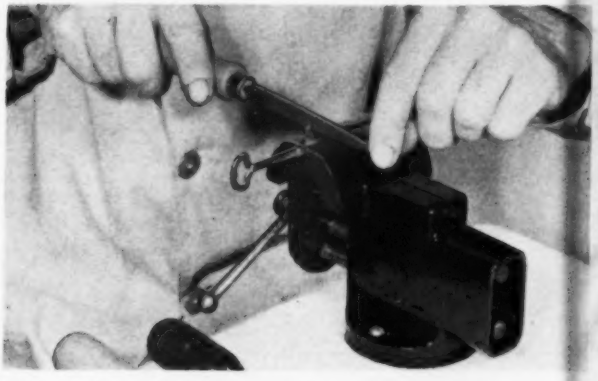
KEY FOR THREE-LEVER LOCK
(SHOWING HOW WARDS ARE USED WHEN KEY IS REVERSED IN LOCK)



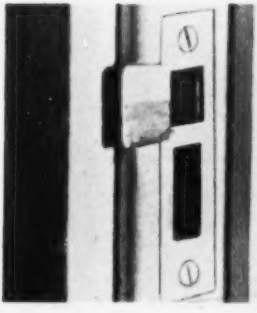
Stops are usually cast on the inside of a lock cover (shown removed above) and wards are filed in the key to clear them



Wards must also be filed in the bottom edge of the key bit to lift levers just enough to clear the stud and throw the bolt



Filing of the lever wards should be done a little at a time, and the key tried often, to avoid getting them too deep



At right, the worn band shows that the latch is missing the plate hole. Tightening on the upper hinge may raise the door enough for it to catch

MACHINE

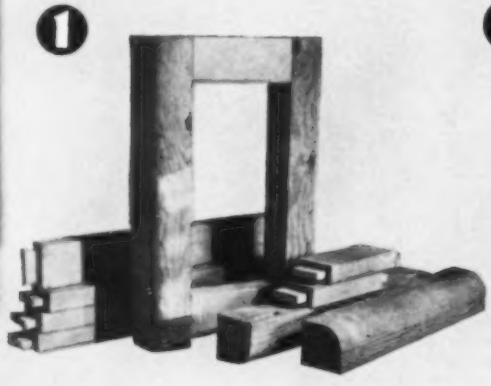
STURDY WOODEN STAND

By C. W. WOODSON

This stand for a circular saw is equally suitable for other power machines

DURING the last few years many home workshops have been equipped with machine tools by owners who appreciate their labor-saving qualities and wish to turn out a wide range of work on a production basis. But as more machines have been introduced, the mounting of the equipment has presented an increasingly difficult problem. Although suitable steel stands for such power tools have been available as optional equipment, the mechanic who takes as much pleasure in building his own shop accessories as he does in using them has often preferred to make his own stands of wood. These men will be interested in the homemade bench illustrated.

This bench is used as a mount for a small circular saw, but it would serve as well, if the dimensions were altered slightly, for a variety



BENCH FOR YOUR SHOP

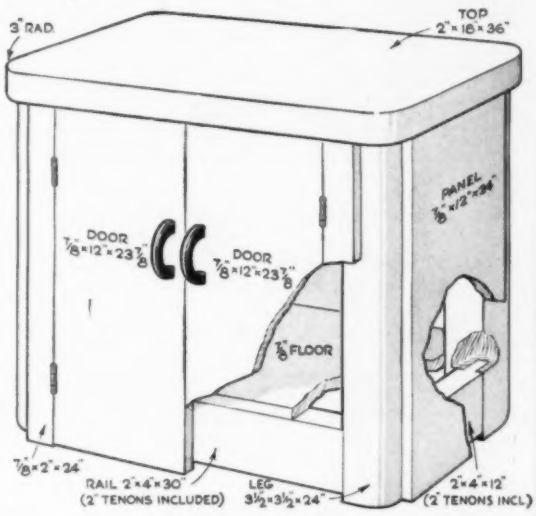
PROVIDES HEAVY-DUTY SUPPORT FOR POWER TOOL

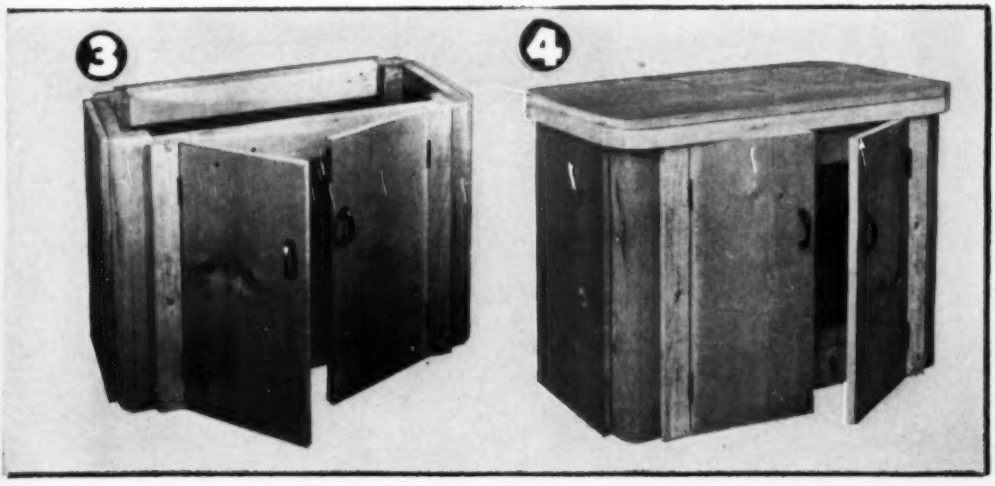
of other machines. It is heavily and staunchly built and will easily support any equipment found in the average home shop. With the addition of shelves its roomy interior can be used for the storage of attachments or other tools, and will be especially convenient for those accessories that the operator must use frequently.

The bench is simply constructed, with no attempt at fine cabinetwork. Top and bottom rails are cut to length and the tenons formed exactly alike by working to gauges set up on the saw table. The legs are mortised with a brace and bit, and the holes squared up with a sharp chisel to receive the tenons of the side and end rails. The outside corners are rounded as indicated.

All top and bottom rails, with tenons cut, are shown along with the heavy bench legs in Fig. 1 at the bottom of the facing page. Figure 2 shows these parts assembled and gives an idea of their strength, while in Fig. 3 the back and ends as well as the two doors, with their modern handles, have been added. In Fig. 4 the bench top has been put on. This top is built up by making a framework of two-by-fours, covered with $\frac{7}{8}$" pine boards. Wide 2" stock, as indicated in the drawing just below, will look as well as the built-up top and perhaps be even more substantial, although the built-up method of construction will be found adequate.

The finished bench may be stained and varnished or enameled in a color matching other shop equipment.



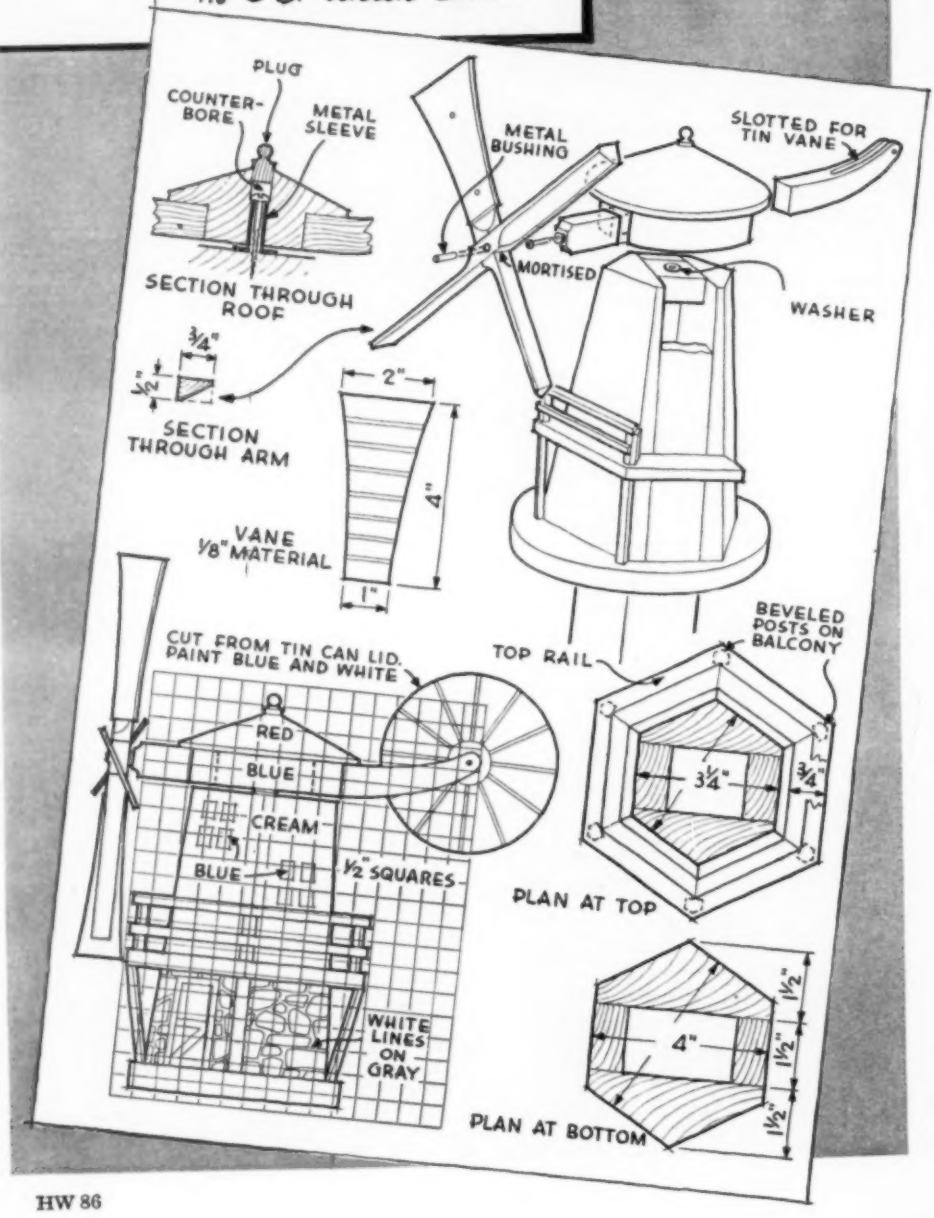


Dear Workshop Editor:

My victory garden is doing its bit, but needs a little brightening up. I think a Dutch windmill might help. Can you tell me how to make one?

M. O'B. Akron Ohio.

A Dutch treat for your garden or lawn can be made in the form of a model windmill spinning in the breeze. Follow the simple construction details on the drawing



NEW SHOP IDEAS

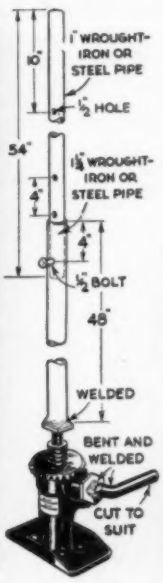
SHARPENING WIRE SCRATCH WHEELS can be done with a simple jig. After prolonged use, such wheels get dull and fail to cut properly, and while reversing the wheel on its arbor will help somewhat, the best remedy is to sharpen and true up the wires. Do this by making a simple jig, as shown, which holds the wheel against the grinder so it can be turned while held on a true axis. Turn the wire wheel slowly by hand with a light pressure against the grinding wheel, preferably contrary to any curve of the bristles.—H. P. S.

Easily Built Telescoping Support Has Numerous Uses

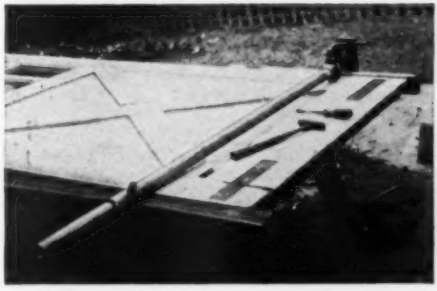
WITH a 48" length of 1¼" pipe, a 54" length of 1" pipe, and an old automobile jack, preferably of the screw type, you can construct an adjustable support that will give valuable service around the shop and home. It will support a pipe vise for threading pipe, hold long lumber being cut on a circular saw, keep sheet metal or wallboard against the ceiling while one is nailing it on, serve as an auxiliary clothesline pole, and so forth.

Drill a ½" hole 4" from the end of the 1¼" pipe. Drill ½" holes 4" apart in the 1" pipe, starting 10" from one end. The smaller pipe, inside the larger one, protrudes 6" to afford a grip for adjusting the setup. A ½" bolt will serve to hold the pipes at approximately the setting desired, and the jack screw will take up the slack.

Weld the 1¼" pipe solidly to the top of the jack. Bend the handle near the jack at a right angle and cut the other end off to suit. This adjustable support, with a piece of angle iron bolted to the smaller pipe at the desired hole, will serve also as a carpenter's clamp, as shown in the photo directly below.—URIAH HILLEGAS.



At left, how the support, set up in a doorway or in a cellar between floor and joist, will hold a pipe vise



Using the Modern

THE United States Office of Education has prepared a series of 16-mm. sound films dealing with the operation of machine tools. These are distributed for the Government by Castle Films, and are used as visual aids in the training of war workers. They are of great value to those preparing for machine-shop work as well as to those already in it. Since your earnings and advancement in war industry will depend largely on what you know, it will pay you to see these pictures when they are being shown in your community or at your plant.

Above, cutting a keyway in a piece of round stock on the milling machine. The stock is clamped fast on a movable table, which feeds it against the teeth of a revolving cutter

As in all machine work, the operator's first duty is to thoroughly brush all dirt and abrasive grit off the working parts, and to lubricate all of these parts and their controls

THE milling machine is an extremely versatile power-driven machine tool, and performs a great variety of operations with speed and accuracy. It is particularly useful when a large number of interchangeable parts must be cut to exactly similar dimensions, and its adaptability is such that it can handle large castings and forgings as easily as small pieces of intricate design.

The two basic elements of the milling machine are (1) a movable table and (2) a revolving cutter. The table carries the work to a multitoothed rotating cutter, instead of revolving it, as does a lathe, or reciprocat-

ing it, as in the case of a planer. The cutter remains in a fixed position, but its speed is adjustable. Cutters of various shapes and sizes are used to suit the job to be done. In the milling machine shown on the facing page, a slotting cutter is being employed. Speeds of cutters may range from 20 to 500 revolutions per minute.

After carefully brushing the bed of the machine and lubricating its working parts, the operator secures the rough stock to the table, which can be brought up or down, sideways or across, as may be necessary to manipulate the work under the cutter. These movements can be made under power by means of rapid-traverse controls on the front of the machine, or by duplicate hand controls at the sides. For precision adjustments, however, the work is fed by manual controls equipped with calibrated dials on which each division represents .001" of table movement.

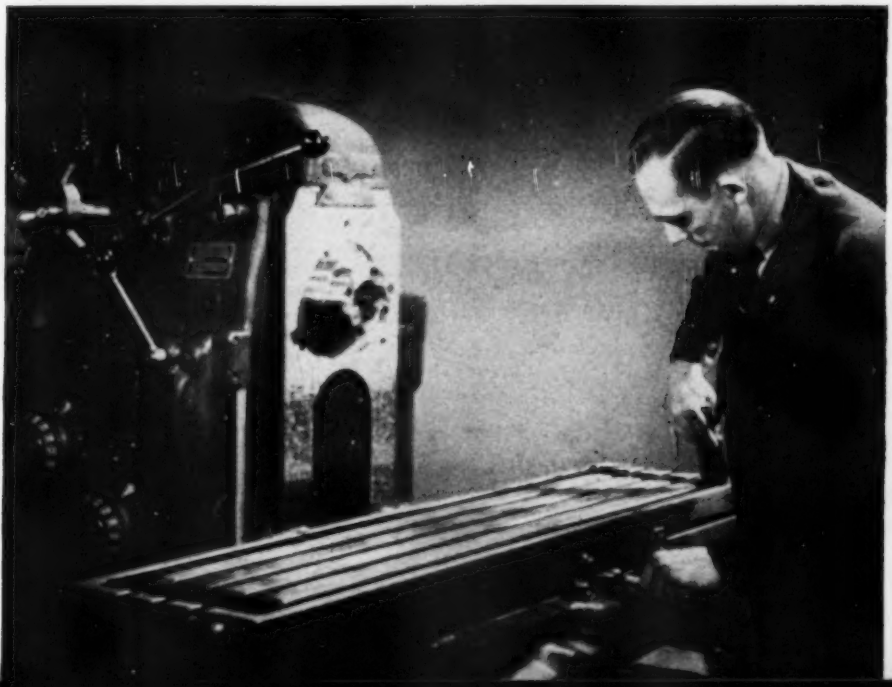
With the work in place, the operator is ready to adjust the revolving cutter. First, he fits an arbor shaft into the power-driven spindle. Spacing collars are used to locate the cutter at any position on the arbor, while additional collars and a key hold the cutter in place when the arbor nut is tightened and lock it on the arbor to provide a positive drive. A large collar is then set on the end of the arbor to act as a bearing for the overarm bracket, which is slid out and locked in place to support the shaft.

The selection and mounting of the cutter depend on the construction of the machine and the type of work to be done. Before it is placed on the arbor, it is necessary to ascertain the relation of the headstock to the table, whether right or left, and to determine the direction of cutting movement and rotation of cutter teeth. In general, the cutter to be used should be as small as the job permits, since a shorter cut will allow for greater feed speeds and requires less power.

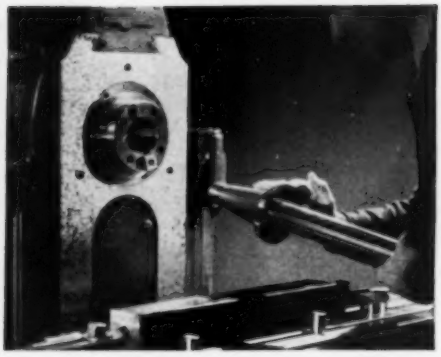
When the motor is started up, the cutter is set in motion by engaging a quick-acting clutch. The work is then carried up to the cutter and is secured against vibration through various levers which lock the knee, saddle, and cross feed. A selective feed indicator, graduated in inches per minute, is set to govern the speed at which the work is fed.

Successful milling depends upon the flexibility of movement of the table, the accuracy with which the work is adjusted in relation to the cutter, and the use of the correct tools at the proper speeds. Excessive speeds should be avoided, as they dull the cutter and produce a coarse surface. [*CONTINUED*]

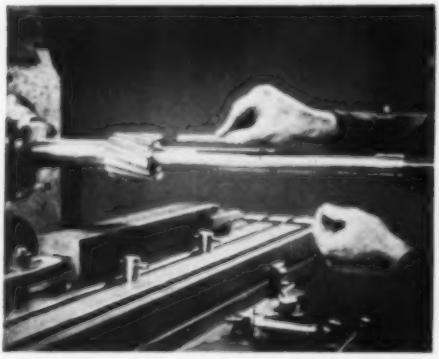
Milling Machine



1 In setting up the milling machine, the work and fixtures must be held securely. The table can be moved up or down in a vertical plane, back and forth horizontally, or in a cross-feed manner



2 The arbor shaft is fitted into a tapered hole in the power-driven spindle, and is secured by a draw-in bolt that passes through the hole in the spindle from the rear. Drive lightly with a mallet

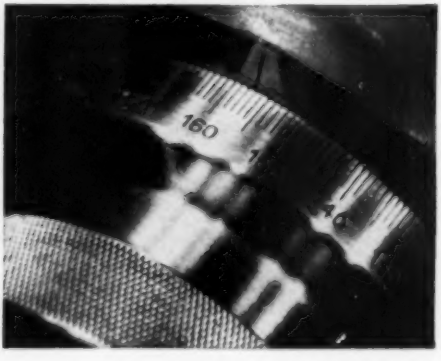


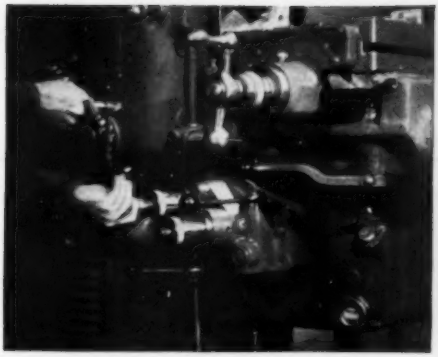
3 The cutter to be used is placed in position on the arbor and is keyed to the shaft. Collars to hold it in place are then added, and a binding nut is tightened. A larger collar fits on the arbor end

4 The overarm is slid out to support the arbor. It is adjustable along its axis and is moved to any desired position and locked by clamps. An outer bearing prevents chatter and steadies heavy cuts

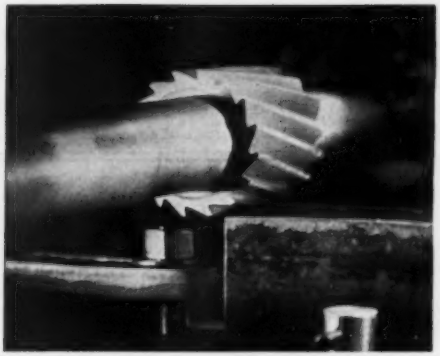
5 With the milling machine ready for operation, the machinist sets the speed of the cutter and switches on the motor, allowing a trial run of a few minutes to check against wobbling or poor fit

6 The work is elevated into position for cutting by power-driven controls, but for more precise adjustments a manual control is employed, having a collar that is calibrated in thousandths of an inch

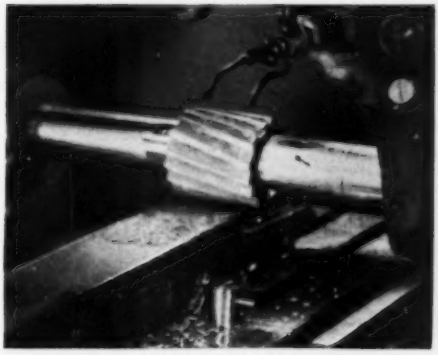




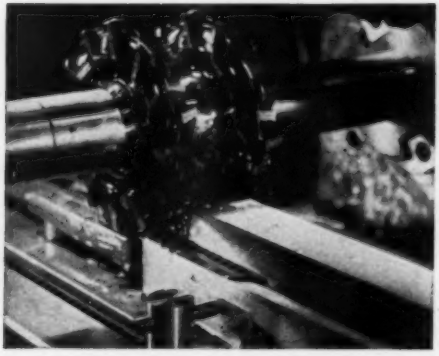
7 If it is not desirable to bring the work up by electric power, these duplicate hand controls may be fitted to the feed levers. The table pivots on the clamp bed and can be swiveled to any angle



8 The revolving cutter is now ready to bite into the rough stock. The speed at which the work is fed is governed by a selective indicator and varies with the material being milled and the cutter used

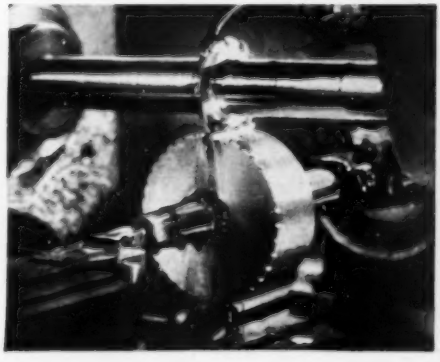


9 The job proceeds with the work being faced, as shown. A continuous flow of oil applied to the cutter keeps it cool, and washes away chips. Milling compounds differ according to the metals machined



10 Milling cutters are usually grouped into four classes: facing, radial, angular, and formed. Above is shown a straddle, or heading cutter of the radial type machining two surfaces simultaneously

11 Below, an involute gear cutter of the formed class is cutting grooves in a gear blank. A fly cutter may also be used for this kind of work, but its single cutting edge requires a finer feed



12 A plain slitting saw cutter makes a keyway in a shaft. If the slot is to extend along its entire length, the feed must not be eased off until the axis of the cutter passes the shaft end

Matching Heart-Shaped Pendant and Pin Carved from Wood

Above, the pendant and pin ready to grace milady's costume

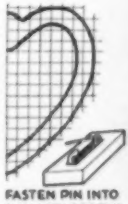
THIS monogram pendant and pin set makes a distinctive personal gift. Any craftsman, with the aid of a jig saw, can turn it out in a comparatively short time. The set shown was made of padouk, a dark-red wood that takes a glossy polish, resembling plastic when finished either with ordinary white shellac or varnish.

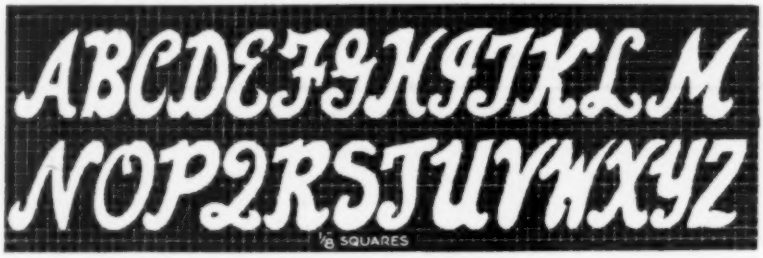
Use wood about ¼" thick, well planed and sanded. Begin by drawing an outline of the heart, with the outer edge about 3/16" wide. Inside this outer rim, arrange the initials. Either two or three may be used. The two pieces illustrated do not match, as they were made with different initials.

The letters of the script alphabet may have to be altered slightly for best arrangement by lengthening their protruding parts. Lay out the letters on ⅛" squares just as they appear on the squares below, and cut with a fine fret-saw blade.

For the necklace, use a discarded chain or a silk cord. The pin on the bar consists of a safety pin set into the groove with double-strength casein glue. Fasten the heart to the bar with a small loop of wire or thread.—ELMA WALTNER.

The letters and the heart outline are laid out on ⅛" squares exactly as shown in the drawing below





LAYING OUT SPIRALS [SHOP PRACTICE]

Fig. 1

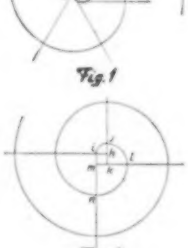


Fig. 2

A SPIRAL is a curve about a fixed point that will make any number of revolutions around that point without returning into itself. The two easiest ways to construct a spiral are to make it the involute of either a circle or a square. To use the circle method, divide the circumference of a circle (the primary, or "eye" of the spiral) into six equal parts, forming a hexagon. Extend the sides outside of the primary, as shown in Fig. 1. With *a* as a center, describe the arc *bc;* from *d* draw the arc *ce*, from *f* the arc *eg*, and so forth, increasing the radius at each step to continue from the part of the spiral last drawn.

To lay out a spiral from a square, draw the square and extend its sides as shown in Fig. 2. With *h* as a center, draw quadrant *ij*. From *k* draw *jl*, from *m*, *ln*. Continue with as many successively larger quadrants as necessary.

While the square method is simpler, it may be found to be less accurate than the circle system. In fact, the greater the number of divisions, the more precise will be the spiral.

POPULAR SCIENCE MONTHLY SHOP DATA

ACCENT ON UTILITY

THREE CRAFTWORK PROJECTS

DESIGNED BY

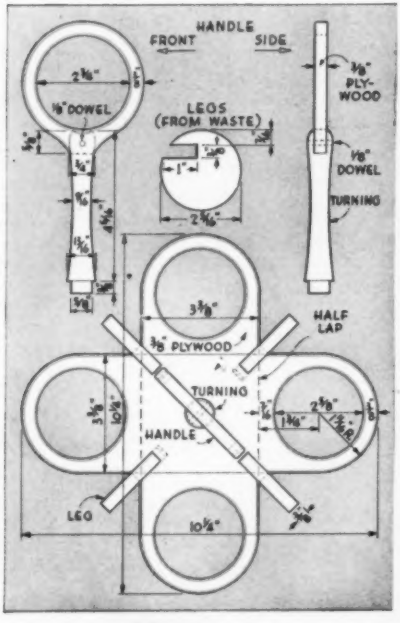
ERNEST R. DEWALT

HANDY REFRESHMENT SERVER. This project is a combination of birch and plywood comprising an attractive and useful server for four glasses of iced drinks. It is based on the use of a minimum amount of material with hardly any waste. Two pieces of ⅜" birch plywood, 3⅜" wide by 10¼" long, are required for the two arms of the base and for the legs, and another piece, 3½" by 3¾", is needed for the ring in the handle, while the handle stem is a turning from ⅞" by ⅞" maple stock 4 11/16" long.

The two pieces for the base are half-lapped, as shown in the drawing, with a 3 7/16" overhang on all four sides to form arms. The holes are cut out with a circle cutter, and the disks are saved for use as the legs, which also serve to join the base halves. All holes are centered on the cross-pieces with ⅝" rims at ends and sides.

In making the legs, lay out a ⅜" notch on the disks as shown in the drawing, and cut out all four at the same time so that they will be uniform. Glue these legs on the arms after all the holes and rims have been smoothed and rounded. The holes in the arms are made to fit woven grass casters, but the diameter may be changed to suit. The glasses shown have a bead to hold them; tapered glasses also would serve.

The handle is also cut with the circle cutter. It has a ⅜" rim that widens out to ⅝" at the bottom to provide a section for joining to the maple turning. The maple



Clocked Project

Average Time 4 hours

part of the handle is turned to the diameters shown in the drawing, with a 5/8" peg left at the bottom for insertion in a hole bored in the center of the base. This should be a good tight fit so that the handle and base can be held together with glue. Notch the top of the turning to a width of 3/8" to receive the handle ring, and bore both the turning and bottom section of the ring for a 1/8" dowel, which is inserted and glued after the inside and outside of the ring have been properly rounded.

Three coats of clear lacquer, rubbed well between coats with fine sandpaper or steel wool, will give a handsome natural finish.

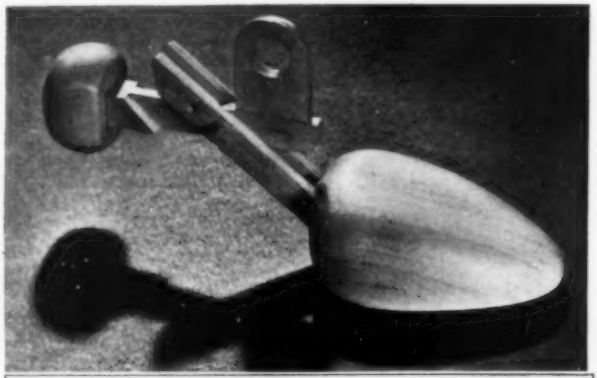
ADJUSTABLE SHOE TREE. Since metal shoe trees are difficult to find, here is a welcome project using nothing but wood. The trees are easily adjusted by removing and reinserting a small peg, and are designed for use with shoes within a range of three half sizes. The wooden construction provides sufficient strength for all ordinary demands, and has the added advantage of having no parts that will tend to rust with frequent use.

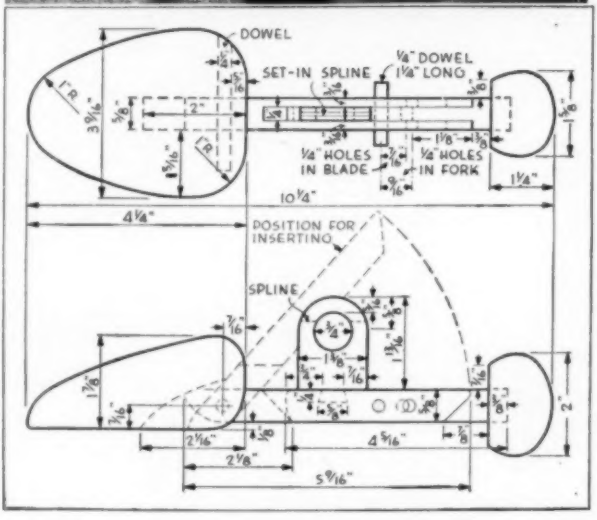
The fork and blade of the shoe trees are of maple, although birch may be used, and the toe piece and heel knob are of whitewood. The hinge joint in the toe piece is either dadoed or formed by repeated saw cuts in a 3 9/16" by 4 1/4" block. The 1/4" hole is then drilled for the pivot peg, after which the block is carved to the shape shown in the drawing.

Shaping of the toe piece is done best by first bandsawing the block to the approximate dimensions and then finishing with rasp, plane, and sandpaper. Make free use of paper templates. These may be cut in any way that is most convenient, one method being to cut them to the outside dimensions of a shoe, and then to reduce them somewhat to allow for the thickness of the leather. Although the trees may be shaped for right and left shoes, this is not necessary, and time may be saved by making them interchangeable.

The fork and blade are of 5/8" square stock. Cut out the middle section of the fork to a width of 1/4", leaving two 3/16" sides. Drill two 1/4" holes 9/16" on centers in the fork, and two similar holes 7/16" on centers in the blade. These provide for adjustment for shoes of sizes 8 1/2, 9, and 9 1/2 when the other dimensions in the drawing are followed. The length of the blade and fork and the position of the holes in them may be altered slightly, however, to fit shoes of smaller or larger size.

The heel piece is turned on the lathe to a 2" diameter, and flattened on the sides. Join the blade into the heel by rounding off the square to a 3/8" by 5/8" peg joint. Dovetail a finger-grip arm into the blade. Bore a 3/4" hole in the upright after a 5/8" upper portion has been strengthened with a 1/16"





Average Time 4 1/2 hours

"Clocked" Project

spline. Have the grain of the spline at right angles to that of the grip arm for added strength. The shoe tree is removed by pulling upward, and inserted in a shoe by folding it up and then pushing down at the center. Finish with three coats of lacquer.

MORTAR AND PESTLE. This double-decker wood-turning project is intended for use in preparing salads, gravies, dressings, or sauces that require spices or like seasonings to be ground or pulverized before mixing with the other ingredients. Select well-seasoned walnut (either crotch or stump wood), and bandsaw a 3¼" by 4¾" block to a cylindrical shape as a preliminary step.

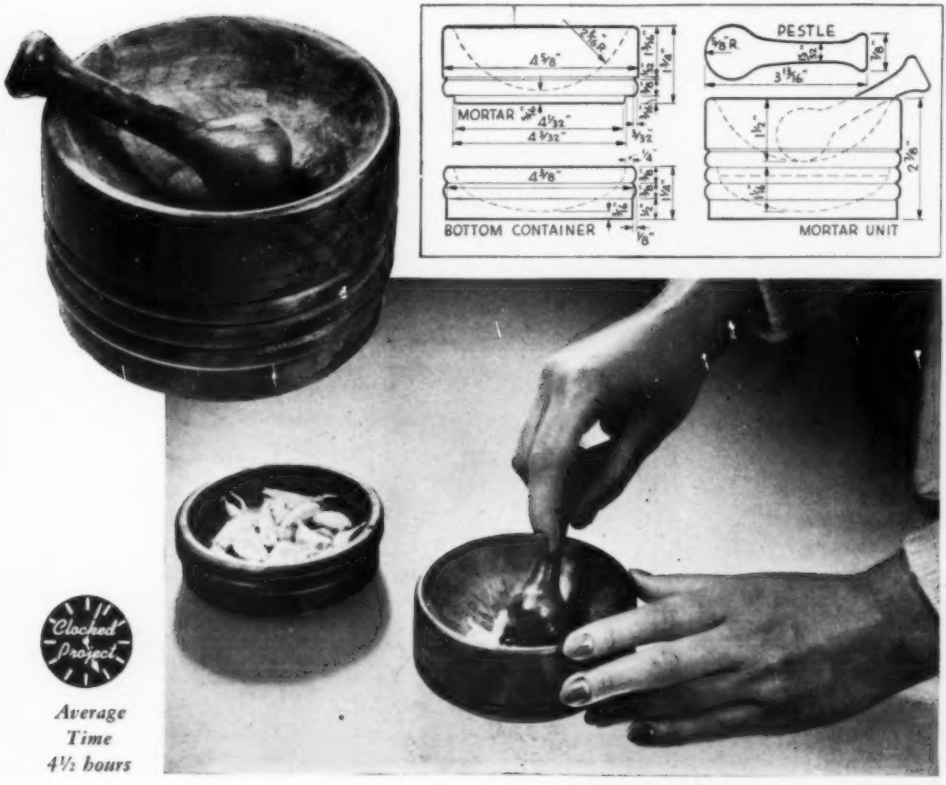
Turn the top portion, the mortar, first on a faceplate or in a wooden chuck turned to fit it. The mortar is 1½" deep, and is turned to a template having a 2 3/16" radius. Finish the piece smooth on the lathe, rounding the mortar well to the sides. The ledge on the bottom is for closure with the bottom container, and has a 3/16" shoulder; it is tapered 1/16", thus coming to a diameter of 4 1/32" at the bottom. After finishing the piece, cut it off with a parting tool.

The bottom portion is 1¼" over all, and has a well 1 1/16" deep, large enough to hold garlic, cloves, spices, or other seasonings. The outside diameter is turned to the same size, 4⅝", as the mortar. Fit both turnings snugly, but not so tight that they cannot be separated when desired by twisting and pulling them apart.

Turn the pestle from 1½" by 4¼" stock, and finish on the lathe to the dimensions shown in the drawing below.

Apply three coats of lacquer, rubbing between each coat, right on the lathe. Put no finish on the well of the mortar or bottom container, and use none at the bottom end of the pestle, as these come into contact with the spices being ground.

TURNED MORTAR AND PESTLE ARE USEFUL CULINARY ACCESSORY FOR PULVERIZING SEASONINGS NEEDED IN THE HOME KITCHEN.



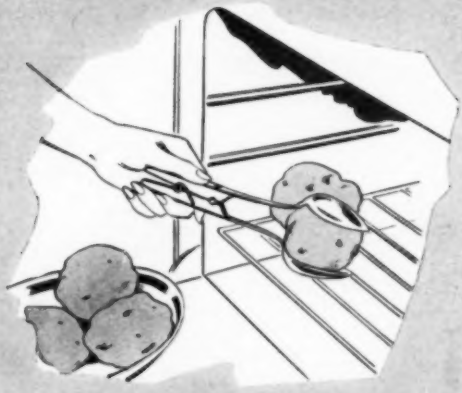
Clocked Project

Average Time 4½ hours

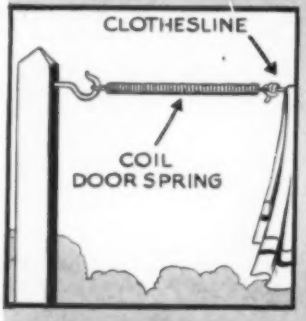
KEEPING THE HOME

A drawer attached to the underside of a rocking chair will hold sewing needs, books, magazines, or stationery. It is handy for use on the porch, or in a summer cottage where drawer space is limited. Paint or finish drawer to harmonize with the chair

Knit a woolen cover for a hot-water bottle, and you'll not only improve its appearance, but increase the comfort of the user. Add a gay pompon, as shown, in a contrasting color

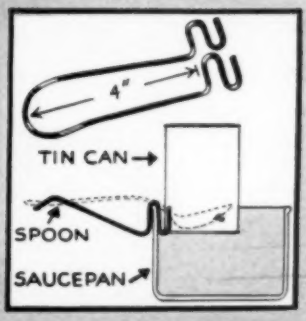


Tongs for removing hot potatoes from the oven can be simply made by riveting two tablespoons to the two parts of a spring-type clothespin



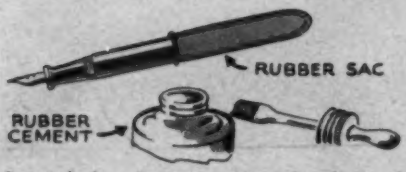
Fixed to one end of a clothesline, a coil door spring keeps the line taut, and prevents it from breaking due to shrinkage

Keep knives sharp by protecting them with the cardboard sheath above. Nicked fingers are also less likely with such a covering

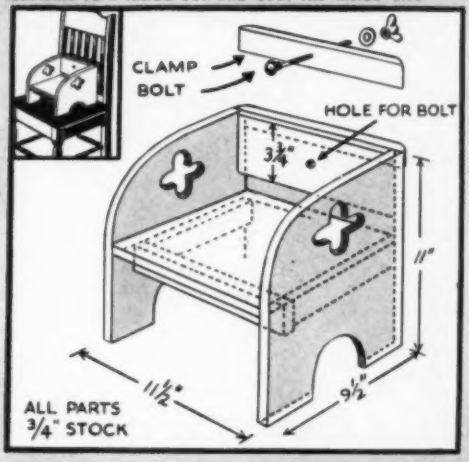


Wire from a clothes hanger, bent and hooked over the lip of a saucepan, holds a spoon or a tin can placed there to drain

SHIPSHAPE

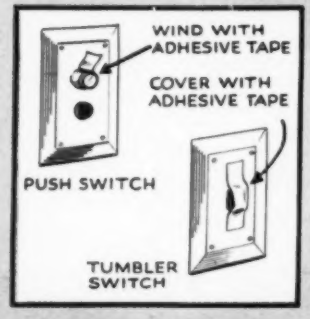


Repair leaking fountain-pen sacs by placing the sac over the pen, as shown, and applying rubber cement. Turn inside out and coat the inside also

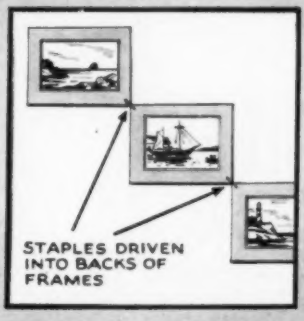


For the youngster who has outgrown a high chair, the seat shown above is ideal. A clamp bar at the back holds it firmly to an ordinary chair, and it is readily portable. The parts are simply assembled with glue and reinforced with screws

A garden hose can be effectively repaired by first painting the break with auto-top dressing, then wrapping it strongly with cloth, followed by stout twine. This stops leaks, and the hose remains fairly flexible

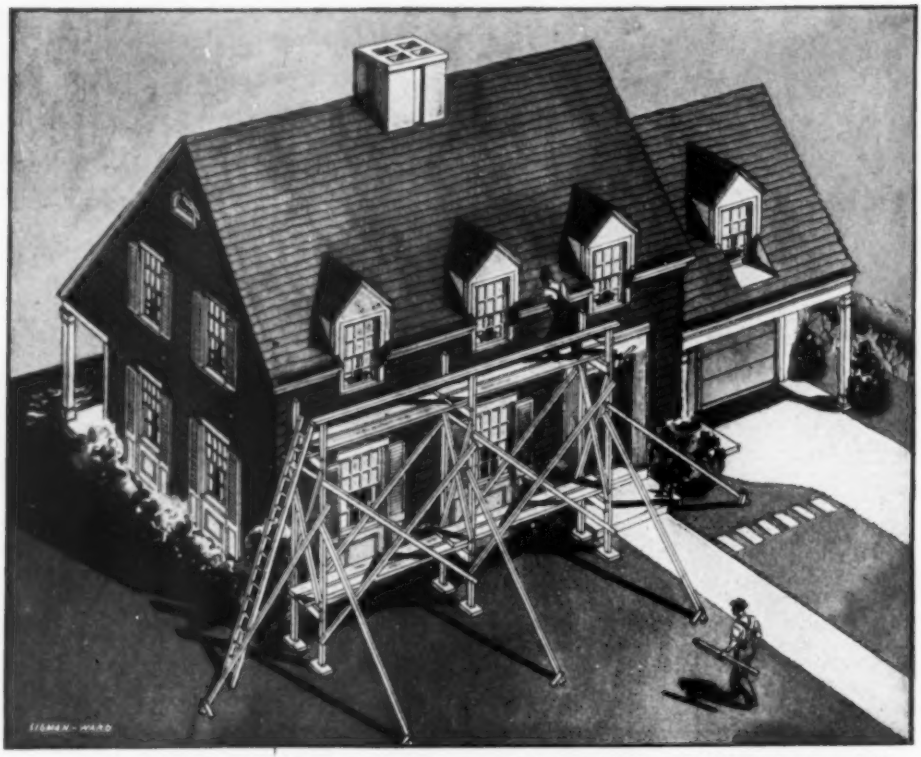


Adhesive tape, placed on light switches as shown in the drawing above, prevents lights from being turned on in blackouts



For keeping stepped pictures in alignment, staples bent from pins are driven in, joining the pictures before they are hung

Twisting a stubborn cap lid with a trouser belt and ruler, as shown, will loosen it. Increased leverage does the trick



For repairs along the whole side of the house, a built-up scaffold is used with well-braced double uprights

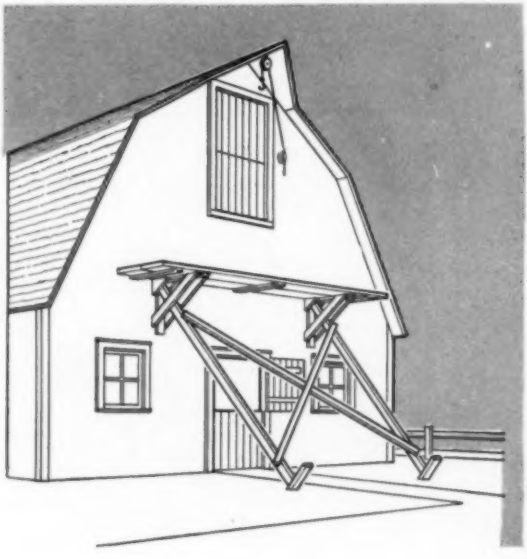
PROFESSIONAL TRICKS AID IN

SCAFFOLDS FOR HOME REPAIRS

How Any Handy Man Can Erect Substantial Temporary Staging

●

By HAROLD R. TERPENY



NEEDED repairs on the outside of houses frequently require a temporary staging, or scaffold. Therefore erection of safe and sane structures of this nature is of special importance to the home owner.

When the entire exterior is to be painted or shingled, for example, stationary or built-up scaffolding is recommended. Spruce is a first-class wood to use for this because it is tough-fibered and will bend without breaking. Suitable boards can generally be rented from a lumber yard for a small sum, the undamaged wood being returned after the work is done. Any cut or broken lumber will, of course, have to be paid for.

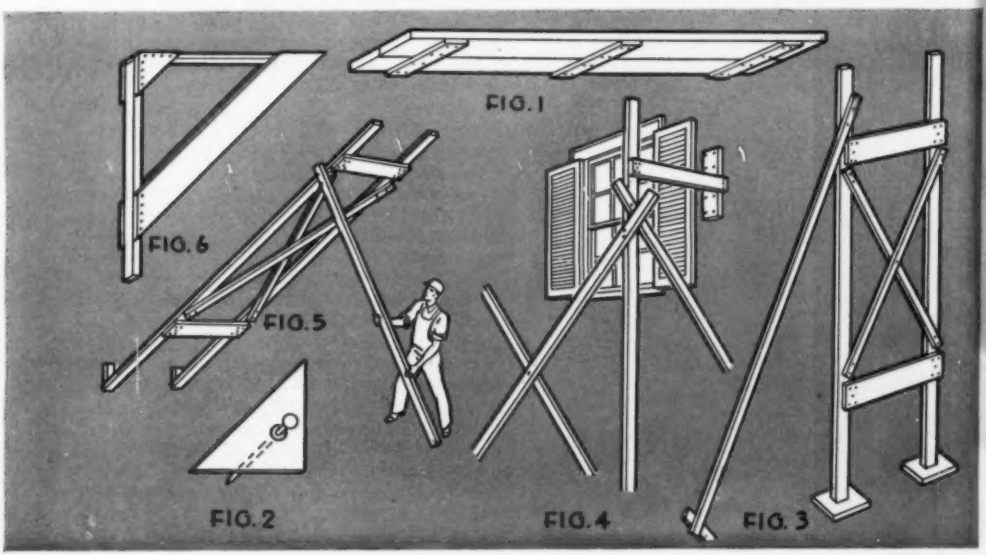
The uprights are 2″ by 4″ lumber, and the crosspieces upon which the planks rest, commonly known as ledger boards, are 1¼″ by 7″ lumber. Upright bracing is 1″ by 3″ stock. Planks are 2″ by 9″ hard pine. For more foot room and greater safety, use two planks side by side and cleated underneath, as in Fig. 1.

For nailing, use regular double-headed staging nails, as shown in Fig. 2. If these cannot be obtained, ordinary No. 10 nails will do, provided you leave the heads sticking out ¼″ or so for easy removal when dismantling the structure. The 1″ by 3″ braces are nailed to the uprights and to stakes driven in the ground. Wherever the braces cross each other, a nail is driven through to prevent them from jiggling back and forth, and to make the scaffold a much stronger unit. Ledger boards, which the planks will rest upon, are secured to the uprights with not less than five nails at each point of nailing, as in Fig. 3. On soft ground the uprights are prevented from sinking into the earth by means of short squares of board, as shown. Double uprights should be not more than 12′ apart, since a greater distance allows too much spring to the planks.

The 2″ by 4″ uprights should be not less than 3′ above the highest plank on the staging. At this level, a 2″ by 3″ guard rail should be nailed on horizontally, as shown in a drawing on the facing page. This is important, as it takes very little to throw a person off balance when working above the ground. A built-up scaffold, with double uprights connected by ledger boards, is good because it does not require fastening ledger boards directly to the house. However, Fig. 4 shows how single uprights can be used by nailing the inner end of the ledger boards to vertical supporting boards nailed to the shingles. When working alone on a hard surface where stakes cannot be driven into the ground, you can erect the uprights by bracing them against a couple of big rocks. Otherwise, use stakes as in Fig. 5.

Another type of scaffolding, using the push brackets of Fig. 6, is shown in the lower corner of the opposite page. This is easy to erect and is especially adapted for use where work is to be done at just one particular spot on the house or barn.

BUILDING WORKING STRUCTURES FOR MAINTENANCE JOBS



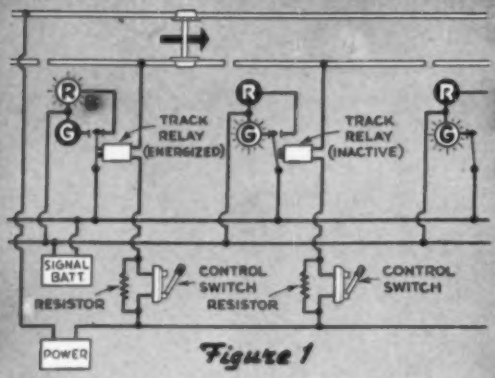


Figure 1

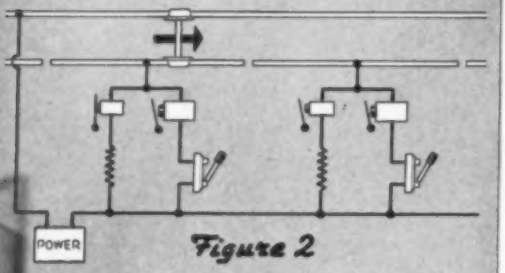


Figure 2

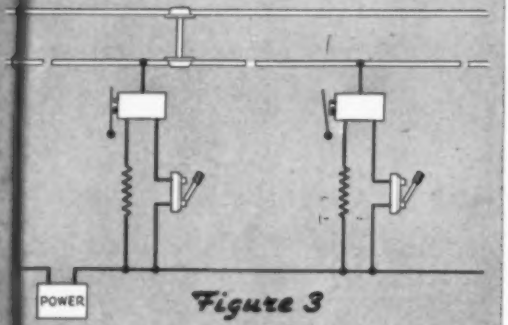


Figure 3

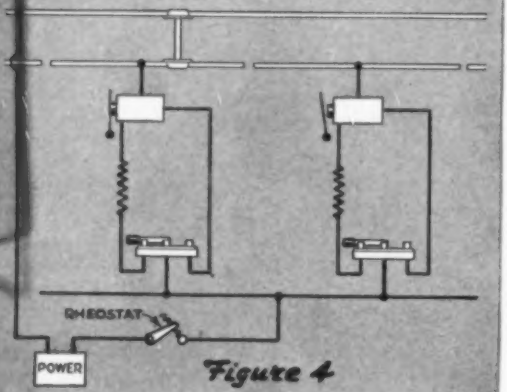


Figure 4

AFTER examining the main characteristics of two-rail operation, in our last article, we began to wire a two-rail pike for automatic signals, carrying things to the point shown in Fig. 1. Here the left-hand block is occupied, and the signal guarding it is at the *stop*, while the right-hand block is vacant, and the signal protecting it is at the *clear*. In each instance the signal is controlled by a track relay. In the occupied block, the mere presence of the train establishes a flow of electricity from the generator to the common rail, through the motor of the locomotive (or through a light on board a passenger coach) to the control rail, and thence through the relay back to the generator. The relay is thus energized, the armature freezes to the magnet, the green-light circuit is broken, and the red-light circuit is closed.

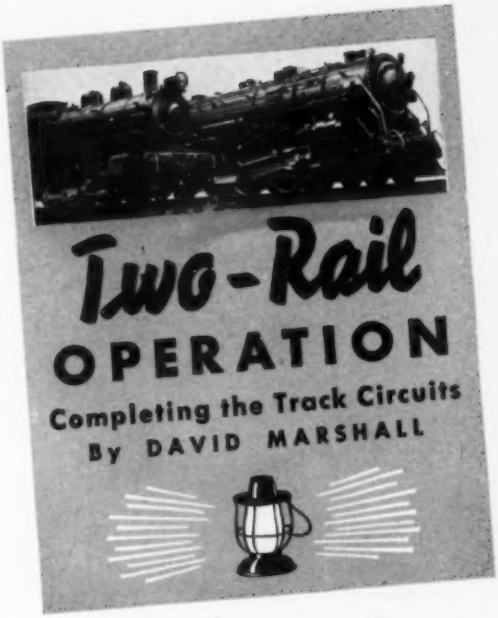
In the vacant block, the green light shows because the track relay is not energized, since there is no train to close the gap between the common rail and the control rail.

TWO-WAY CIRCUIT. What is rather special about Fig. 1 is the fact that the track relay is in series with the locomotive; that is, the power that drives the locomotive must pass through the relay. This is the distinguishing feature of two-rail automatic signaling.

The first objection to it is that when you shut off power and bring your locomotive to a stop, the relay becomes inactive resulting in a false *clear*. But we have solved that in Fig. 1 by inserting a resistor in a circuit that runs around the control switch. When the control switch is open—as in Fig. 1—there is no train movement within a given block; but there is still, through the resistor, a minute flow of electricity that will energize the relay but will not stir the locomotive. Thus, as long as any block is occupied, there is a never-ending flow of current through the windings of the locomotive and the winding of the relay. It may be a powerful flow, driving a double-headed freight train, or it may be too weak to budge a 6-wheel switcher; but it will always work the relay.

DIVIDING THE RELAY. There is a second objection. As it stands, the relay must be sensitive enough to pick up on the minute flow of current through the resistor, yet husky enough not to burn out when trains are working under full power. Such a relay is not unheard of; and if you operate an HO or an OO pike, with a spread of only a few volts between your minimum and maximum flow, you may be able to get what you need inexpensively.

On an O-gauge pike, it's likely to be a



different matter. Let us consider the average O-gauge layout with good locomotives that start rolling (dead speed) on 8 volts and reach their maximum speed and pulling power on 20 volts. That is a spread of 12 volts through the control switch alone. It becomes greater if the current through the resistor runs to as little as 4 volts. In such a case the relay would have to work on anything from 4 to 20 volts. Such relays are not unobtainable, but they are costly—so much so that the average model railroader could not think of buying them.

To get around that difficulty, we divide the relay, and get, as in Fig. 2, a little fellow and a big, husky one. The little one is the more sensitive; it operates on 1 volt and does not get too hot on 4 volts. We hook this one up in series with the resistor. The big fellow operates on 8 volts and can stand 20—at least for as long a time as any train, working on full power, takes to run through the block. And this husky relay, which is not hard to get and not too costly, we hook up in series with the control switch.

Thus far, then, we have solved the cost problem, and we have one relay to pick up on a suboperating flow of current and another to pick up on a much heavier flow.

RECOMBINING THE RELAYS. An obvious fault with this arrangement is that both relays do not work together. In Fig. 2, the left-hand block is occupied, the control switch open, and the train standing still. The little relay has picked up on current passing through the resistor, while the big relay has not, and we must assume that the effect of this (see Fig. 1) must be to cause both red and green lights to show.

You can get around that by wiring the signal differently, but an easier way is to take the coils of these two relays and wind them separately around the same core. Wind both wires in the same direction and keep them insulated from each other throughout the winding, but bring them together at the rail end to form a single wire. In this way we combine the two relays of Fig. 2 in a single relay. (See Fig. 3.)

This new relay differs from others only in having two separate coils. Its action is the same. It picks up when the requisite current flows through either of its coils—2 volts through its high-resistance coil, or 20 through its low-resistance coil.

CUT-OUT SWITCH. But if we leave the thing as it stands in Fig. 3, we complicate our operating problem by adding to the load. If the train in Fig. 3 were actually running, the control switch would be closed, and power would be passing through both coils of the relay at the same time. Nothing would be gained by that; indeed, there would be a loss of power which, multiplied a few times over, would amount to something worth considering.

So it becomes important to cut out the high-resistance circuit once the low-resistance circuit is established by the closing of the control switch. How this is done by a single-pole double-throw knife switch is illustrated in Fig. 4. On your control board you would not have anything so crude, but you must have what will do precisely the same job—a single-pole double-throw toggle switch. With one of these, either circuit must always be closed, the other always open. Then, as long as the block is occupied, the relay will be energized.

Figure 4 also shows the position of the rheostat, close to the power source. This controls the voltage that goes to this or that block separately through the various control switches. It delivers to the locomotive through the low-resistance coil a maximum of 20 volts, and is so adjusted that it must deliver a minimum of 6 volts. That, passing through the low-resistance coil, is too little to move a locomotive; passing through the resistor, it is still enough to operate the relay.

To meet demands, the resistor ought to reduce 20 volts to 4. In that case, the minimum flow of 6 volts from the rheostat would be cut to a little more than 1 volt. Your relay will have to be sensitive enough to pick up on that.

Carved leaves are attractive

Hand-Carved Fruit Tray

THIS attractive tray appeals to both the beginner and the experienced wood carver. Make it of a piece of fine-grained wood such as mahogany, walnut, gumwood, or even poplar or whitewood, about ⅞″ by 10″ by 15″. The finished tray will be 9½″ wide by 14″ long.

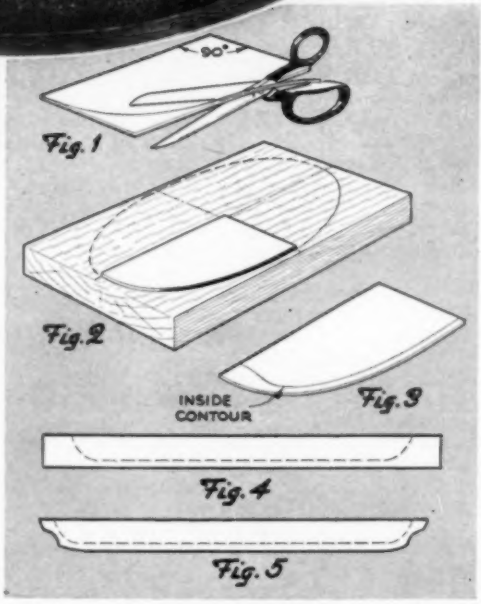
Use a piece of thin cardboard exactly 4¾″ by 7″ for the outline pattern. This must be square along one edge and one end. Draw one quarter of an oval on this paper and cut it out, leaving the edge and end square as in Fig. 1.

Draw center lines on the surface of the wood, both lengthwise and crosswise, at 90 deg. to each other. Align the pattern accurately on these and trace around the outside of it four times to draw the oval wanted (Fig. 2).

Trim the pattern along the curve about ⅜″ from the edge, but square the end across inside, leaving approximately 1″ for the handle part, as in Fig. 3. Now trace the reduced oval on the wood for rough carving.

Rough out the entire inside of the tray to about ½″ in thickness at the bottom. Cut only within the inner oval and trim the edges out concavely (Fig. 4).

Decide on your design (see Fig. 6), lay out one fourth of it as a pattern, and transfer it to the work. Natural forms such as leaves may be adapted by copying them on a heavy paper pattern.



Balance and symmetry depend to a large extent upon accuracy in fitting and tracing the pattern

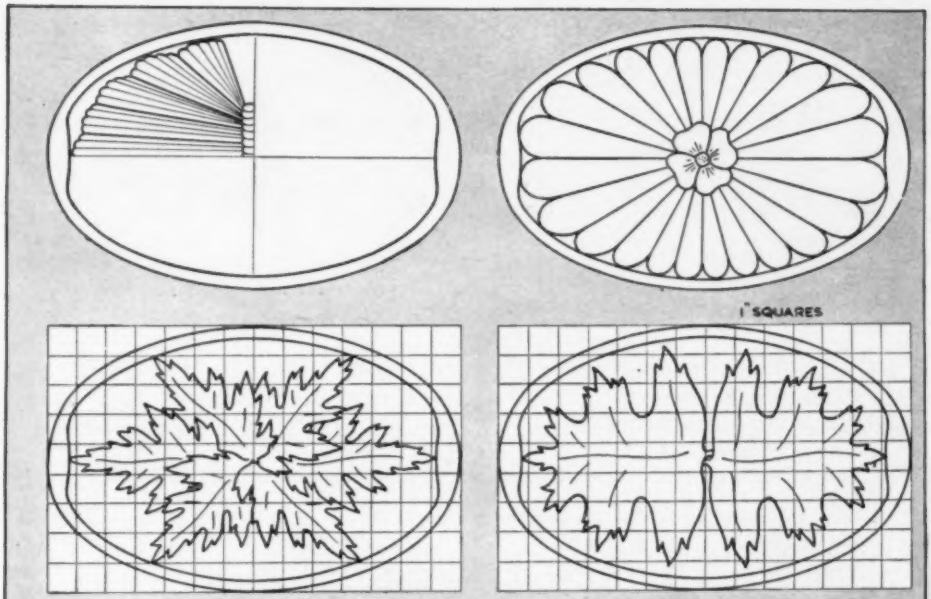


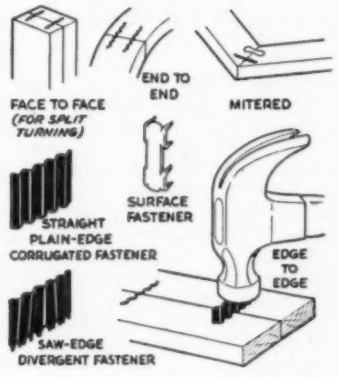
Fig. 6 Suggested Designs

In selecting your pattern, keep the general shape of the tray in mind so the carved area will conform

When the carving is finished, sand very lightly—a few chisel marks left in the design add to its looks—and bandsaw to the outside line. If a power saw is not available, use a handsaw and trim to the line with a file, plane, or spokeshave.

Undercut the outside as shown in Fig 5. Be careful to follow the line of the inside as much as possible so that you will not cut through into the design. Gouge out the underside of each end to form the handles, and sand smooth. Finish with stain, wood filler, shellac, and one or two coats of well-rubbed varnish.—LEONARD F. MERRILL.

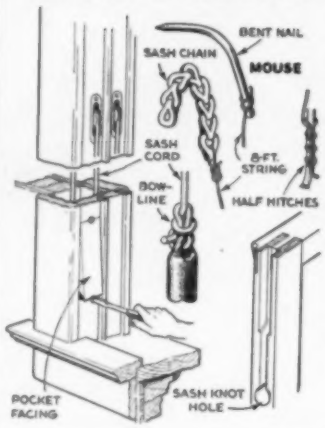
USING WOOD FASTENERS [*WOODWORKING*]



There are two kinds of metal joint fasteners in general use—corrugated nails, and surface fasteners. Both can be used regardless of the direction of the grain in the work, and both hold very securely. Best known are the corrugated fasteners. Specialized uses for them, modifications of those illustrated in the sketch, are constantly being found. They may be used either with or without glue. For good work, fit joints well and drive the corrugated fasteners much like ordinary nails, but be sure to strike them on the ends as well as on the centers to prevent distortion. Underneath shelves, or in other hidden places, simply drive them home; but on exposed surfaces and on work to be painted, set them with an ordinary nail set, and putty. Corrugated fasteners tend to draw the joint open on the opposite side; therefore, hold the joint flat until the glue dries, or use fasteners on both sides. Surface fasteners, unlike corrugated fasteners, cannot be set.

POPULAR SCIENCE MONTHLY SHOP DATA

REPLACING DAMAGED SASH CORDS [SHIPSHAPE HOME]



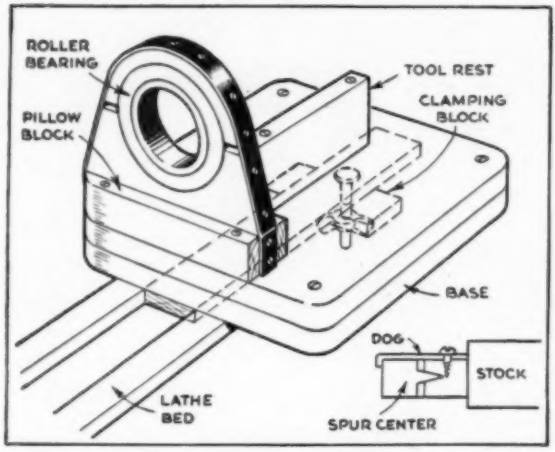
TAKE off the stop on the side of the defective cord and swing the lower sash outward, exposing the knot. Pry this out, removing the parting bead if necessary. Take out the screws from the pocket facing and pry it out, after which the weight can be removed for cutting away the cord. Make a "mouse" as illustrated, pass it through the pulley and out the opening, drawing the cord with it. Untie the string and tie the cord to the weight with a sure knot. Swing the sash back toward the stile, pull the cord until stopped by the weight, and cut it 6" below the sash knot hole.

Tie the sash knot and force it into the hole, laying the cord into the groove. Test the sash in the runs by raising and lowering, making necessary adjustments in the cord length by retying the knots. Drive a small nail through the sash knot, replace the pocket facing, and put the sash in the frame, finally nailing the stop in place.

Sash cord can be cut in lengths of about 5' before installing, with a loop tied in one end of each piece to prevent it from slipping through the pulley. Upper sash cords are replaced in the same manner as lower ones.

POPULAR SCIENCE MONTHLY SHOP DATA

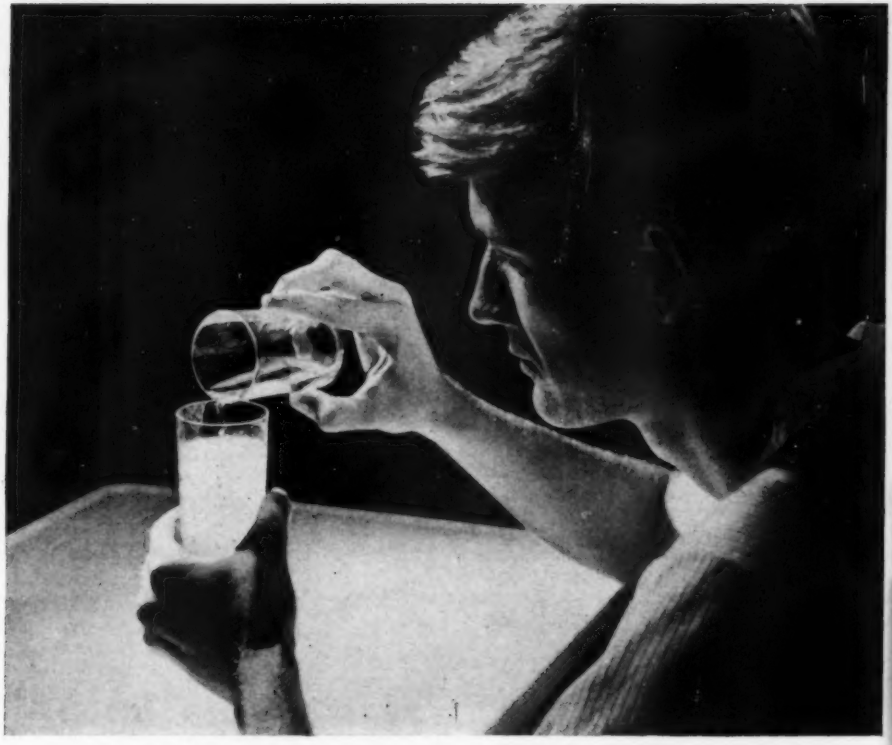
Steady Rest on Lathe Increases Production



THIS homemade "traveler" or roller-bearing steady rest for a small woodworking lathe gives the same advantage as a hollow-spindle lathe but will take work of larger diameter. I have used it for turning wheels as large as 1½", cutting each off and starting on the next without the usual delay involved in remounting or recentering stock.

The stock is first turned between centers to the required diameter, care being taken to keep it as uniform as possible. Then the tailstock is backed up and the traveler mounted on the lathe bed. The stock is passed through the roller bearing and fastened to the spur center with a lathe dog, then turned as required and used up to the roller bearing. After that, the wing nut is loosened and the traveler slid up toward the headstock, bringing more of the material into use.

To line up the roller bearing with the headstock, turn a plug on the screw center to make a snug fit for the inside of the bearing. Then mount a piece about twice the thickness of the bearing and turn a hole to the outside diameter of the bearing. Remount both plug and bearing on the spindle and slip the turned pillow block on with the grain of the wood horizontal. Slide the base up to it. Now the base line of the pillow block can be scribed. Centering in the plug, and with a radius ⅝" greater than the bearing, scribe an arc to outline the top of the pillow block. Two straight lines to a point 1" above the base line complete the outline. After shaping, trim to thickness by taking an equal amount off each side down to 1" above the base line. Then simply saw the block in half and fasten the upper part down with a strip of metal to clamp the bearing. Mount a tool rest on the base as shown. To turn stock smaller than the inside of the bearing, make a wooden bushing.—E. W. MARSTON.



The Element with a Dual Personality

ALUMINUM, INDUSTRY'S LIGHTWEIGHT CHAMPION, ACTS CHEMICALLY AS BOTH AN ACID AND A BASE

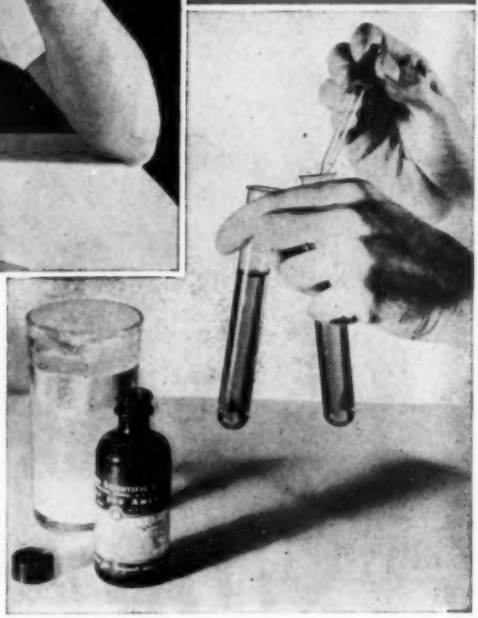
WITH a bit of aluminum from a discarded pot, plus some alum and a few chemicals found in any home laboratory, you can demonstrate several interesting and little-known facts about this useful metal. You can make aluminum salts that react both as acids and as bases, learn how aluminum helps make fast colors in the dye industry, account for some odd reactions of aluminum utensils to food and cleaning compounds, and show what role aluminum plays in baking powder.

Oddly enough, this light, silvery-white element now so seriously needed for airplane and other machine parts is the most abundant and widely distributed metal in the earth's crust. Almost all soils, clays, and rocks contain aluminum in some form, and a great many minerals, including rubies, sapphires, bauxite, and feldspar, are aluminum compounds. It is only the difficulty of releasing the pure metal from its various compounds that prevents aluminum from being the cheapest and most commonly used metal in the world.

Because of its tremendous affinity for oxygen, aluminum is never found uncombined in nature. That is why the surface of aluminum is always thinly and invisibly coated with a film of oxide which, luckily, inhibits further oxidation. A simple chemical stunt, which prevents this oxide from forming, will show you vividly how active aluminum really is.

Clean a scrap of aluminum with steel wool; then rub a few grains of mercuric chloride briskly over the cleaned spot with a cloth or cotton wad moistened with water,

In dyeing cotton, aluminum hydroxide is used to make the dye adhere better. At left, the cloth, after being dipped into solutions of aluminum sulphate and aluminum hydroxide, is finally placed in the dye



until the aluminum becomes coated with metallic mercury. Now rinse and dry the aluminum. Almost immediately, thin filaments or "whiskers" of aluminum oxide begin to rise from the metal. These continue to grow until they are an inch or more long, sometimes until the metal beneath has been entirely eaten away. This rapid oxidation would also attack aluminum utensils and even streamlined trains and airplanes, if the thin coating of oxide that first forms did not protect them!

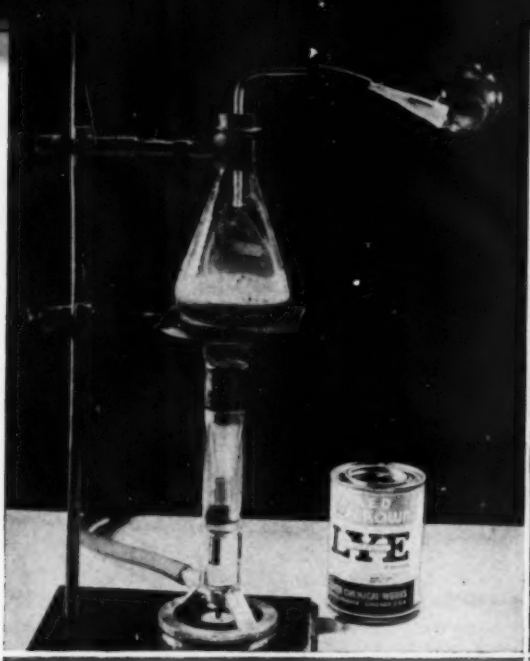
Caution: As mercuric chloride is very poisonous, be sure to clean up any spilled grains and wash your hands thoroughly after this experiment.

As you know, bases neutralize acids, and acids neutralize bases, in each case producing compounds known as salts. However, there are also certain chemical elements and compounds which are amphoteric, or dual-natured, acting as weak bases in the presence of acids, and as weak acids in the presence of bases. Aluminum hydroxide is one of these, as can be proved by a simple experiment.

First, make some aluminum hydroxide by dissolving a little common alum (which is a double sulphate of aluminum and potassium) in half a glass of water, and adding ammonium hydroxide (household ammonia will do). A white, almost insoluble precipitate of aluminum hydroxide forms which slowly settles to the bottom of the glass. Continue adding ammonia until no more precipitate forms. Then let the glass stand until the smell of ammonia has gone.

To prove the dual nature of aluminum hydroxide, add a little of the clear upper liquid in the glass (which contains a small amount of the hydroxide) to a universal indicator solution that has been made slightly acid with dilute hydrochloric acid. The aluminum hydroxide neutralizes the acid. Now add a little hydroxide to a similar indicating solution that has now been made slightly basic, or alkaline. Again the solution becomes neutralized!

Aluminum shows its dual nature in still another instance by liberating hydrogen when acted upon by either acids or strong alkalies. Aluminum scraps in hydrochloric acid yield hydrogen readily. It is not so well known that they will also yield hydrogen in a strong solution of sodium hydroxide, or lye. Put a little lye solution in a flask, as shown in one of the accompanying photographs. Add small pieces of aluminum and heat the flask gently until a strong reaction begins. Thereafter the reaction will continue without further heating. You may prove that the gas is hydrogen by blowing



Aluminum has the strange property of being able to liberate hydrogen from acids or strong bases. Above, aluminum scraps gently heated in a solution of lye generate hydrogen. The bubble shown, filled with hydrogen, will rise to the ceiling

Aluminum resists corrosion because of an invisible, thin coating of oxide which forms on its surface. Above, this coating is prevented from forming to show how active aluminum really is. Rub a few grains of mercuric chloride with a dampened cloth over a clean bit of aluminum. Rinse and dry the aluminum, and almost immediately thin filaments of aluminum oxide begin to rise from the metal, as seen in photo below

← How aluminum reacts in two ways is easily demonstrated. Just a few drops of aluminum hydroxide added to an indicator solution made acid will neutralize the acid; a like quantity added to indicator solution made basic neutralizes the base

bubbles with it that will rise to the ceiling.

Ordinarily, aluminum should never be cleaned with alkalies such as soda or lye, which attack the metal. However, there is a trick whereby you can clean aluminum with alkalies and prevent these substances from corroding the metal. Add only 1 percent as much sodium silicate as washing soda to a 5-percent solution of the soda in water, and the alkali will clean harmlessly.

Animal fibers, such as silk and wool, readily take up most dyes and hold their color. Vegetable fibers such as cotton, however, are seldom color fast when dyed by direct processes. These almost always need chemical assistants. Here again, aluminum hydroxide becomes a helper.

Dip a strip of cotton cloth in a dye bath made of diluted ink. Rinse the strip, and you discover that most of the color washes away. Now dip a similar strip first in a solution of aluminum sulphate (alum will do) in water, and then in a solution of ammonium hydroxide. Dip this treated strip in the ink solution as you did the other strip. The color will be darker, and very little of it can be rinsed away.

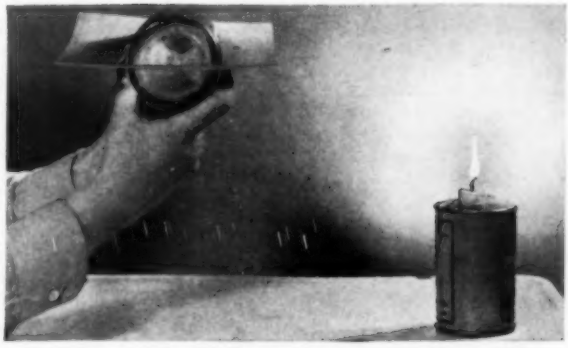
What happens is this: the aluminum sulphate on the cloth is changed into aluminum hydroxide when it is dipped into the ammonia, and this hydroxide is precipitated into the fibers of the cloth, where it assimilates the dye. Since the aluminum hydroxide is insoluble, the dye cannot be washed away easily.

Aluminum, in the form of potassium alum or sodium alum, is often used in baking powder, where it acts as a harmless acid salt. Mixed with baking soda and water, it generates carbon dioxide bubbles which cause the bread or cake dough to "rise". Mix a little alum with baking soda, and add water. The mixture immediately effervesces. Mix flour with the two dry ingredients, stir in water, and the mixture swells like dough.—KENNETH M. SWEZEY.

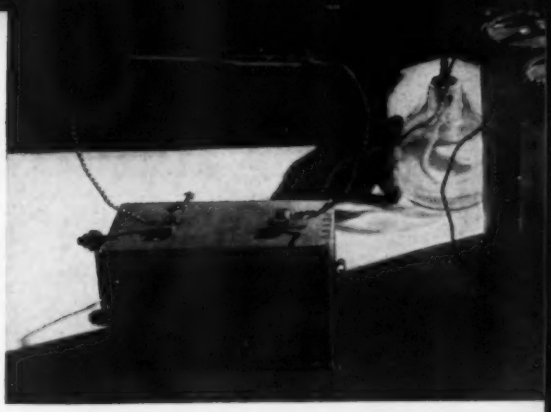
THE VOLUME OF AN IRREGULAR BODY, such as a stone, a piece of coal, or the like, can be easily determined with a spring balance and a jar of water. First, weigh the object in air; then weigh it in water. According to the principle discovered centuries ago by Archimedes, the difference in weight of a given object will be equal to the weight of an amount of water of the same volume as the object. Since fresh water weighs a little more than ½ oz. per cubic inch, or one gram per cubic centimeter, a simple calculation will determine the volume of the water, and thus the volume of the object. At the same time, you may quickly determine the specific gravity of the object by dividing the weight of the object in air by the weight in air minus the weight in water. For example, if an object weighs 15 oz. in air and 5 oz. in water, the specific gravity would be 15 divided by 10, or 1.5.

HOW WATER PRESSURE increases with depth, yet exerts an equal force in all directions at any given depth, is vividly demonstrated with the apparatus shown at the left. Connect a piece of bent glass tubing to a thistle tube having a thin rubber membrane stretched over its mouth. Colored water is poured into the open end of the glass tube to serve as an indicator. If the thistle tube is then lowered under the surface of water in a jar, the liquid in the outer leg of the tube will rise, continuing to do so as the thistle tube goes deeper into the water. If, however, the thistle tube is swung around at various angles, while kept at a given depth—mouth down, mouth up, or mouth to the side—the liquid will remain at the same height, indicating that the water pushes upward, downward, and sidewise with equal pressure at any fixed level.

IS THE SUN WHERE WE SEE IT? The answer to this seemingly simple question is—no. The sun is often seen before it has reached the horizon in the morning, and after it has passed the horizon in the evening. This phenomenon can be explained by the fact that in this case light is bent, or refracted, by our own atmosphere. The effect can be duplicated on a small scale by using a candle to represent the sun, and a soda bottle filled with water to represent the earth's atmosphere. A piece of cardboard marks the horizon. Arrange the bottle and candle as shown in the photograph, then look above and along the "horizon." The candle, which is actually far below the card, will seem to be above it. Furthermore, as sunlight must travel about 8 minutes to reach us, we never see the sun as it is, but always as it was 8 minutes ago.

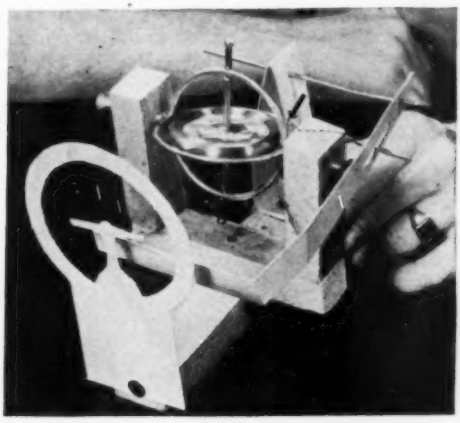


home EXPERIMENTS



GLASS CONDUCTS ELECTRICITY. Although a good insulator when cold, glass becomes a fair conductor of electricity when heated. You can demonstrate this quickly and simply in your home lab. Draw out a short length of glass tubing in a flame so that its central portion has a bore of only a few millimeters. Into the ends of the tube place leads from the secondary of a spark coil, or a small neon-tube transformer. Now excite the coil. If sparks do not immediately jump through the tube, heat it with the flame from an alcohol lamp. As soon as the tube is hot enough, sparks will leap through it. The sparks will, under favorable conditions, continue to jump even after the flame has been removed, and may finally melt the glass in the small part of the tube, thus producing two sealed glass electrodes. If the spark has been hot enough, it will still continue to jump between these two glass electrodes!

FLUORESCENT LIGHTING. The reason for the great efficiency of fluorescent lamps can be readily demonstrated with some fluorescent paint and a small argon bulb. The paint can be made by mixing a paste of quinine sulphate and dilute sulphuric acid. Coat half the bulb with paint and, when it dries, turn on the current. The coated side will give out considerably more light than the uncoated side. The paint, upon being bombarded by ultraviolet rays from the plates in the bulb, gives out visible rays of great intensity. In regular commercial tubes, the fluorescent coating is on the inside of the tube, rather than the outside. This protects it, and at the same time utilizes those ultraviolet rays that cannot pass through the glass.



ARTIFICIAL HORIZON. How does a pilot, flying blind, know whether his plane is ascending or descending? His instrument board has an artificial horizon—a gyroscopic device that indicates the plane's relation to the real horizon. Mount a toy gyroscope in a U-shaped frame to tilt freely at right angles to the wheel axis. Solder a stiff wire to the gyroscope frame as indicated by the arrow. Let this project into a slot in a cardboard lever that is pivoted at one end and bent at the other. If the base is now tilted as a plane is in climbing or diving, the spinning gyroscope will not tilt with it, but will continue spinning parallel to the earth. When the plane is climbing, the horizon bar will be below the indicator; in descending, the bar will be above it.

REBUILDING THAT OLD

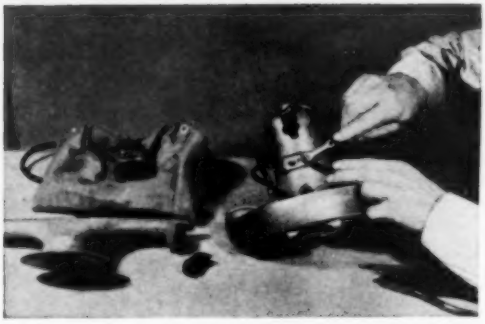
Expert Reconditioning in the Home Workshop Can Restore to Further Use Many Appliances and Other Electrical Machines That Have Long Been in Discard

By HAROLD P. STRAND

MAKE it do, or do without! To these alternatives that are daily becoming apparent to more and more Americans, there can be added a third. Rebuild it! This is particularly true of a worn-out vacuum cleaner. No matter how old it may be, or how long it has lain in dusty discard, it probably can be made to work almost like new. Electric mixers, drills, and other machines having universal-type motors can be rebuilt in much the same way.

The first step in reconditioning your vacuum cleaner is to remove and discard the bag, saving the clamping ring at the bottom and the spring-clip bar at the top for use with a new bag. The procedure of disassembling will differ with various

STEPS IN RESTORING A WORN-OUT



1 Remove the front suction housing by swinging the top clamp to one side and tapping the unit off its pin. Then disconnect the wires from the binding posts

4 The two parts of the motor unit are separated to give access to the inside of the motor and its armature and other parts that may be in need of repair

VACUUM CLEANER

makes, but in general should follow the order described for the cleaner shown.

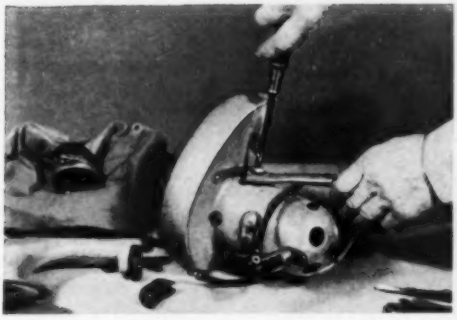
Remove the front suction housing by swinging its top clamp to one side and tapping it off its hinge pin. Then disconnect the wires as in Fig. 1. Take off the handle by loosening two machine screws (Fig. 2). If the spring that keeps it upright is broken, replace it. Bending will probably suffice to restore lost tension.

In taking out the fan, first remove the three screws in the cover. Some fans are locked on the shaft with a nut and may be threaded on as well, in which case a small wrench thrust through a housing opening may be used to grip a square part of the shaft or to bear against the inner motor-cooling fan. A setscrew locks the fan shown. Back of the fan are two machine screws holding the motor unit to the fan housing. These are removed next (Fig. 3), and the two parts are separated, as in Fig. 4, for access to the inside of the motor.

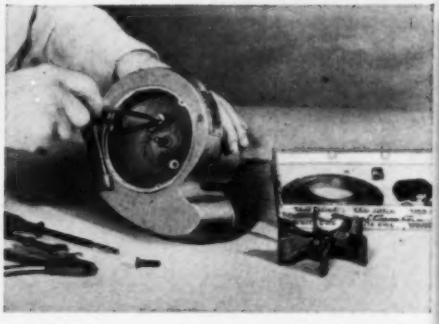
Inspect the armature to see that no wires are unsoldered from the segments, and check the insulation for char indicating burned-out windings. The only effective test is to place the armature on a growler, as in Fig. 5, to test for shorts, opens, and grounds that may require rewinding or exchanging the armature for a rewound one. Any electric shop will make the tests if you have no growler available.

The commutator probably will be grooved

VACUUM CLEANER WITH THE USE OF FEW NEW PARTS



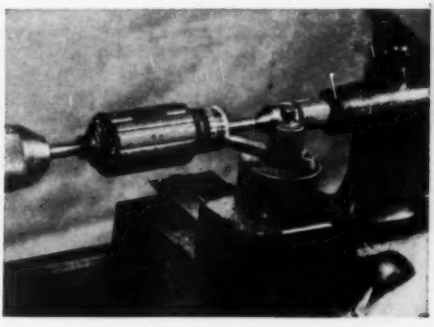
2 The handle is taken off by removing two screws. If spring that holds the handle up is broken, replace it. Bend it to restore lost tension



3 After removing the cover and taking out the fan carefully, remove the two screws behind it. These hold the motor unit to the fan housing

5 An armature can be tested effectively only on a growler. Look for shorts, opens, and grounds. Defects here may mean a rewinding job

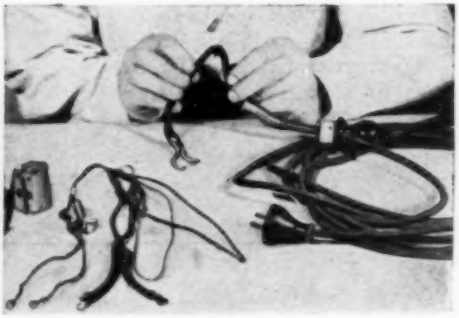
6 Turn down the commutator in the lathe if the surface shows grooves made by the brushes. Take only light cuts and finish with fine sandpaper



7 All parts should be cleaned thoroughly of grease and dirt. Those containing no wires may be washed in carbon tetrachloride or kerosene

8 Test the armature shaft for play at both of its bearings. Any worn bearings must be replaced or made to fit with emergency repairs

9 Connect a jumper across the brush guides to get a through circuit in the field windings, and then make tests for open circuits and grounds



10 Draw the wires out of the handle along with the switch. If the cord is broken near the handle, cut it off at the break and reconnect it

from the brushes, and it should be turned smooth in a lathe as in Fig. 6. Make several light cuts, and finish with sandpaper. Slightly undercut the mica separators between the segments, using a special tool or a piece of hack-saw blade with the "set" ground off until it makes a cut the width of the mica. Hold it to cut as you pull it toward you. Cut the mica down a little further than the copper surface, taking care not to cut into the copper; then sand.

Clean grease and dirt off all parts, washing those that contain no wires in carbon tetrachloride or kerosene (Fig. 7) and drying with clean cloths. Clean the motor-field unit with a round bristle brush; then wipe the exposed inside metal parts with a small piece of cloth dampened in the solvent.

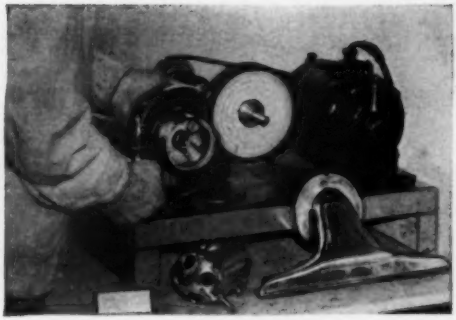
Pass the armature shaft through its bearings (Fig. 8) and test for play, being sure there is no lost motion at either bearing. If wear is evident, new bearings should be obtained or some stopgap measure taken. You might press the bearing sleeves out, using a shoulder arbor in the vise, and then press them into a hole of slightly smaller diameter that has been drilled into ½" steel. When pressed out again, the sleeves will have holes reduced in size. Build the outside surface back with solder, and finish with a reamer.

Another method is to make a hack-saw cut lengthwise of the bushing, squeeze the cut together in the vise, and wrap a piece of thin shim stock around the bearing without letting the ends overlap. This can be pressed in the hole as before, and a reamer used to finish the inside.

The field windings should be tested with a series lamp (Fig. 9) for open circuits and grounds. Connect a jumper across the brush guides to get a through circuit of the two field sections. The lamp should light when the test prods are touched to the binding posts, but not when they are touched to the aluminum casing and either post.

Removing the screws in the top knob and switch will allow the wires to be pulled out of the handle (Fig. 10). The switch toggle lever is removed by loosen-

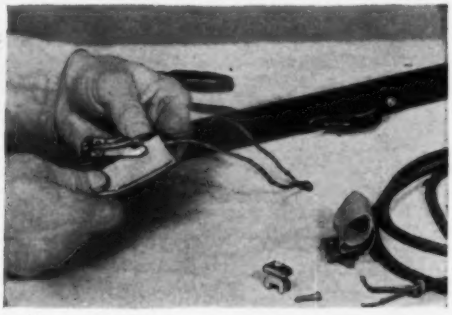
11 To patch the braided covering, apply one layer of friction tape, wind heavy thread over it, tie the ends, and finish with shellac



12 Polish the aluminum parts on a cloth buffing machine, which will give a high luster. Use aluminum paint on parts that do not finish well

13 When reassembling the cleaner, bush wheels if they wobble, take up end play in the armature shaft, and replace worn carbon brushes

14 Before putting the switch and wires back in the handle, clean the switch contacts with sandpaper and make final tests with a series lamp



ing one screw in its face. Draw the wires out with it. If the cord is broken near the handle, which is the usual case, it can be cut off there and reconnected. Test for other breaks with the series lamp. Apply a single layer of ½" friction tape over damaged spots in the outside braided covering, and follow with a close winding of heavy black thread, as in Fig. 11, and a coat of shellac. Minor damages on rubber cords can be patched with rubber tire putty or tape and thread. If the copper is brittle or the insulation badly worn, get a new cord.

Finish the handle by polishing the aluminum fork on a cloth buffing wheel and applying a coat of black enamel to the remainder. The other aluminum parts of the cleaner are also polished on the cloth wheel (Fig. 12). A fine scratch wheel will take rust and dirt off small parts.

In Fig. 13 the cleaner is being reassembled. Bush wobbly wheels, take up excessive end play in the armature shaft with thin fiber washers, and replace the carbon brushes if they are too worn. Clean the switch contacts with fine sandpaper drawn between them, as in Fig. 14. Test the switch and wires again with the series lamp, and then draw them back into the handle with the aid of a fish wire. Attach the handle and the new bag; then refill oil or grease cups to complete the job.

A cleaner having a motor-driven brush is overhauled similarly. The brush wears too short in time and may need to be replaced. If the rubber belt is badly stretched and cannot be replaced, it may be necessary to remove the brush and use the machine as a suction cleaner only. Clean hair and lint from the brush and brush bearings, and test the latter with the belt off to see that they allow the brush to turn easily. If the belt is not put back on correctly, it may fly off the motor pulley, so look for markings or test it before reassembling. The underside of the brush should turn in to draw in dirt. Excessive wear may occur in the bearing near the pulley due to belt tension, but regular lubrication minimizes this. Test for lost motion with belt off.

FIRST STEPS IN ELECTRONICS

Part 2

ELECTRONS ON THE RADIO

IN ORDER to unfold the story of radio communication, it is necessary to roll back the curtain of time to a stormy day of 1901. On the rugged shores of St. John's, Newfoundland, a group of men had succeeded after a fierce struggle in sending aloft a large kite attached to a copper wire. The end of this wire was attached to an electrical receiving device. After several adjustments, the group gathered around the equipment and waited expectantly. Suddenly an electric earphone that had been making haphazard sounds buzzed three times, stopped, and again buzzed three times. The men cheered loudly. Long months of hard preparation had at last been crowned with success. The three dots of the letter "S" had traveled thousands of miles across the Atlantic from Poldhu in Cornwall, England, and had proved to a doubting world that almost instantaneous communication was possible over vast distances. Guglielmo Marconi, who transmitted the signals on his first attempt, is generally credited by the public with inventing radio communication. His contribution, however, was to make commercially successful the work of Clerk-Maxwell, Hertz, and other physicists.

In the comparatively short time that has elapsed since Marconi's colorful achievement, tremendous progress has been made.

A diagram of the important components of a modern broadcasting transmitter is shown at the top of page HW 116. At *A* is a graph representing an alternating current. Its amplitude (strength) is indicated by vertical displacement of the peaks above and below the axis. Its frequency is the number of cycles per second along the axis.

The oscillator, *by generating an alternating electric current*, makes electrons move to and fro at frequencies of from 550,000 to 1,600,000 times per second, depending upon the frequency at which the station is licensed to operate. The graph of the output of the oscillator is shown in curve *B* The feeble output of the oscillator is made stronger by the radio-frequency amplifier, and its effect on the oscillation is shown in curve *C*. Note that the distance the graph extends up and down—the amplitude of the signal—has been increased.

In order to transmit speech, the amplitude of the carrier wave must be modified by the modulator, in accordance with the sound variations of the voice. Sound waves strike the microphone and produce minute electrical currents varying at the rate of 16 to 16,000 times per second. These are called *audio-frequency* variations because they are audible. The graph of the audio-frequency output of the microphone is shown in curve *D*. The output of the microphone is increased by the audio-frequency amplifier with the result indicated in curve *E*. The output of the amplifier is used to modify, or modulate, the carrier wave from

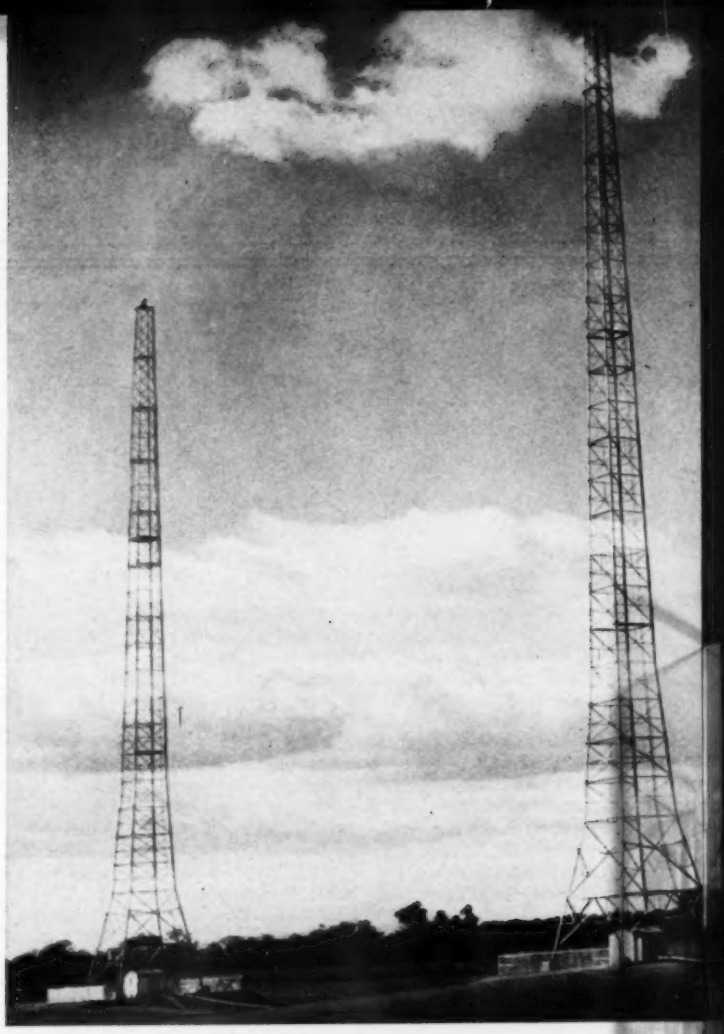
Left, master control point in transmitter room of a commercial broadcasting station Transmitter controls like those at right are used to amplify and modulate radio-frequency energy fed to an antenna system (right, above), which broadcasts the waves we "tune in" at home

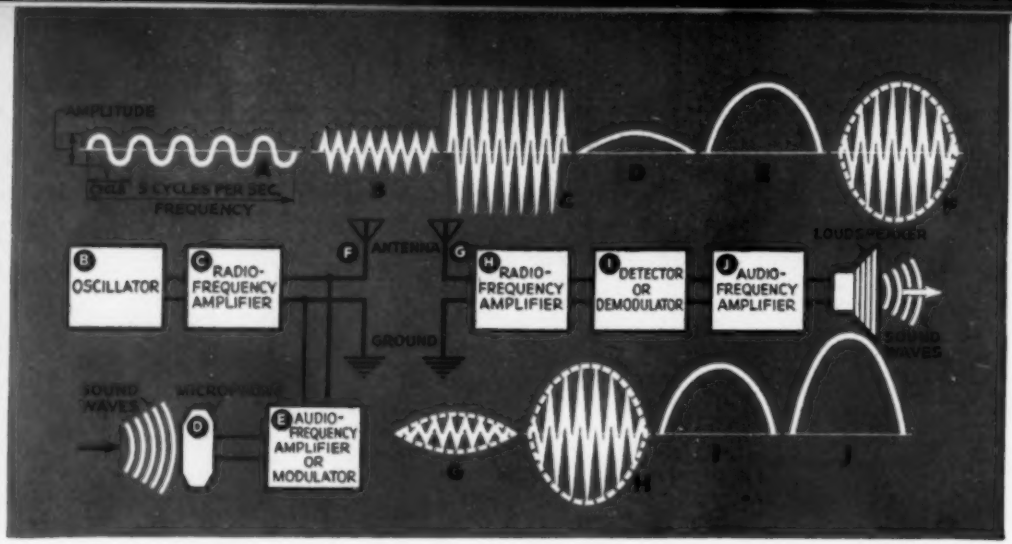
By
CHARLES I.
HELLMAN
Physics Instructor, Bronx High School of Science, New York

the radio-frequency amplifier, as in curve *F*. The modulated carrier wave is then fed to the antenna, and the oscillating motion of the electrons in the antenna sets up disturbances called *electromagnetic waves*.

Electromagnetic waves produce a modulated radio-frequency current of very small value in the antenna of a receiver. Look at curve *G*, Fig. 2. The radio-frequency amplifier builds up this feeble current to the strength of curve *H*. The modulation, or audio component, must be separated from the radio-frequency carrier wave before it can be made audible, and the detector performs this demodulating function as in curve *I*. The weak audio-frequency energy is amplified by the audio-frequency amplifier (curve *J*), and is fed to the loudspeaker which converts the electrical energy into sound. This completes the broadcasting cycle.

If the radio-frequency carrier is rejected in the





process of modulation, you may ask, why not transmit the modulation energy directly? The answer lies in the fact that modulation is at audio frequencies and that radiation from an antenna is negligible at these frequencies, but is considerable at radio frequencies. Therefore, a radio-frequency (RF) wave is required to act as a *carrier* for the modulation.

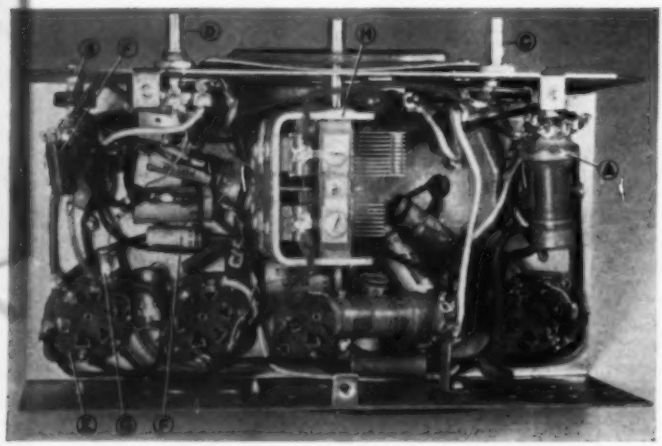
An old radio may be disassembled and the parts used for many simple experiments in electronics. Remove the knobs by loosening the setscrews that hold them to the shafts. Carefully turn the set upside down and remove the screws holding the chassis to the cabinet. Occasionally some parts, such as switches or pilot bulbs, are fastened to the radio cabinet, as well as to the chassis of the set. These must be unfastened from the cabinet before removing the chassis.

Remove tubes and pilot bulbs. Care must be used in lifting off the screen-grid clips, or the grid terminals on the tubes may be pulled off.

You are now ready to begin disassembling the set. Turn the chassis over. Using a soldering iron, unsolder the small resistors. It may be necessary, when unsoldering connections, to twist one wire while the soldering iron is applied to the joint. Next, unsolder in order the small condensers, all connections to sockets, and connections from parts to the chassis called "ground connections." Be careful not to touch the hot soldering iron to paper condensers, coils, or other parts that may be damaged by heat. Do not dismount sockets from the chassis.

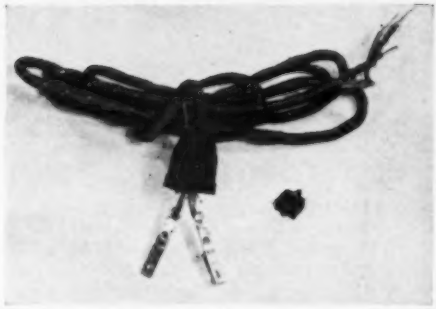
When the small parts have been removed and all connections unsoldered, you are ready to remove the larger pieces of apparatus with a screw driver. If any parts are riveted or welded to the chassis, it is preferable to leave them on it rather than risk damaging them. The tuned-radio-frequency transformer or oscillator coil, large fixed condensers, chokes, switches, volume and tone controls, and loudspeaker are the parts that will probably be dismounted at this point.

Save all the parts and hardware obtained from the receiver. A subsequent article will explain how you can make good use of them.



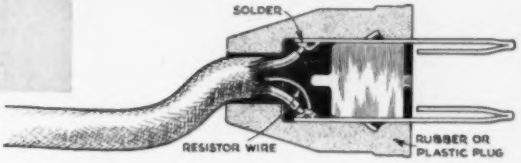
A, radio-frequency transformer; B, radio-frequency choke; C, switch; D, volume control; E, socket; F, small fixed condensers; G, carbon resistor; H, variable condenser

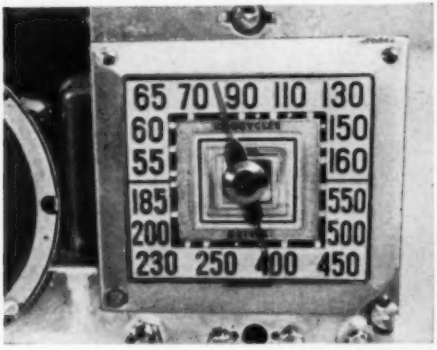
Servicing Your Radio



Yanking on a line cord often causes a break in the resistor wire. To avoid this, grasp the plug when removing it

LINE-CORD BREAKS, which occur most frequently in the built-in resistor in a cord of the type shown at the left, may be the reason a receiver goes dead. It is advisable to check this resistor if tests show that all the tubes are good. Sometimes it is possible to solder the thin resistor wire back to the prong, as shown in the sketch; if not, the whole line cord must be replaced.

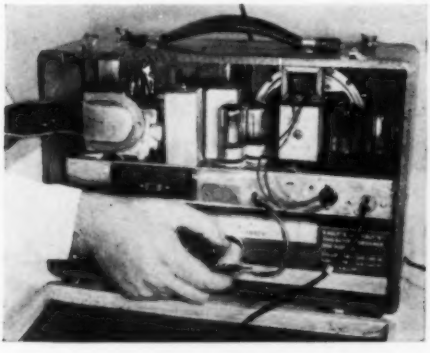




SOME TYPES OF DIAL POINTERS can be repaired easily with common liquid cement. If one cannot be set on the proper station indicator because it has come loose from the center plastic piece to which it was attached, remove the chassis from the cabinet and apply the cement as indicated in the drawing below. Best results can be obtained by removing the pointer assembly from the dial face and laying it flat, as shown. This will keep excess cement from spotting the dial face should any drip off the pointer during the application.

IF BATTERY OPERATION on a three-way portable is fuzzy, but reception is satisfactory on both A.C. and D.C., replacement of the battery pack is usually necessary. "B" batteries showing 75 volts on a meter have been known to have such high internal resistance that the voltage to plates and screens was reduced to as little as 35 volts.

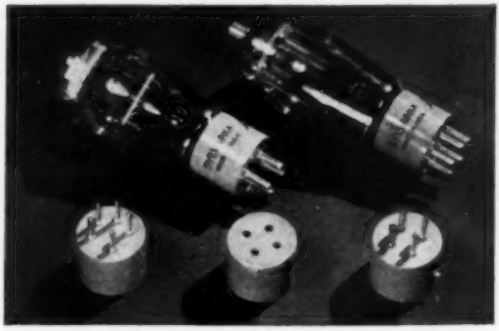
BURNED-OUT BALLAST TUBES need not put a receiver out of service permanently even if the tubes cannot readily be replaced with new ones. Satisfactory results can be obtained by removing the old line cord from the set and substituting a new line cord having a built-in resistor of a resistance value matching the tube heaters.



radio ideas

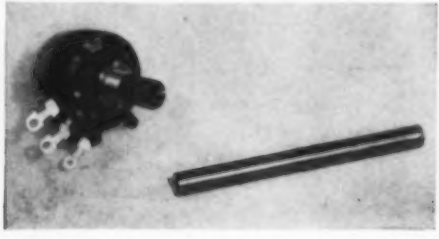
THIS PORTABLE MICROPHONE fits over the shoulders to leave both hands free. It is especially suitable for police and other call systems where the broadcaster must be engaged in writing or taking notes while using the instrument. At sports events, carnivals, and the like, it will be found highly portable; in addition, it permits the announcer to use both hands for moving other equipment. The unit is light in weight, and its shoulder harness fits snugly and comfortably. The mouthpiece, mounted on a flexible gooseneck-type column, can be held close to the mouth, and will give great volume without danger of feedback.

PLASTIC BASES FOR TUBES are being made to take the place of the customary porcelain bases heretofore used on tubes operating on ultrahigh frequencies. The new plastic is said to serve as efficiently as the ceramic material, and has one distinct advantage since it is not nearly as fragile as the regular porcelain. This is an extremely important point when it is considered that much of the equipment in use by the armed forces operates on ultra-high-frequency bands and therefore requires tubes fitted with special bases for these bands.



REPLACEMENT VOLUME CONTROLS equipped with slotted attachments that automatically fit old shafts eliminate the problem of shaft sizes and knob fitting. Ten different types in the popular resistance values, tapers, and taps are available. Each control has a switch that can be put in operation only when a small lug on each side is removed, thereby enabling the control to be used without the switch when necessary.

INSULATION CAN BE STRIPPED automatically by placing the end of a wire in the new wire stripper below and pressing the handles together. One jaw clamps down on the insulation adjacent to that being stripped, while a second cuts through the insulation and removes it from the end of the wire. The tool can also be used for cutting copper wire and nickel-plated copper wire, but not wire made of iron or steel.



PRECISION RADIO-TIME CONTROL

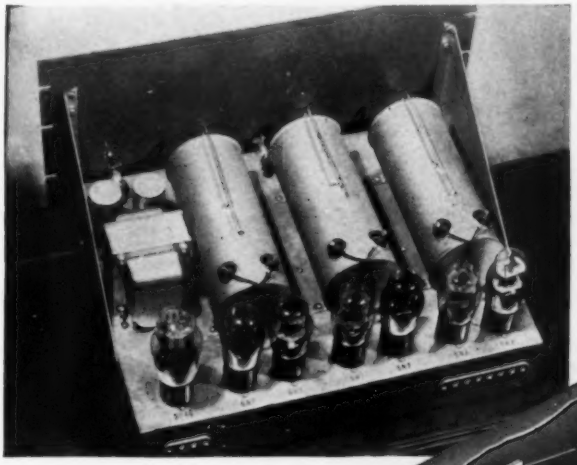
Tuning-Fork Vibrations Amplified by Series of Vacuum Tubes Keep 200 Studio Clocks Synchronized

• • •

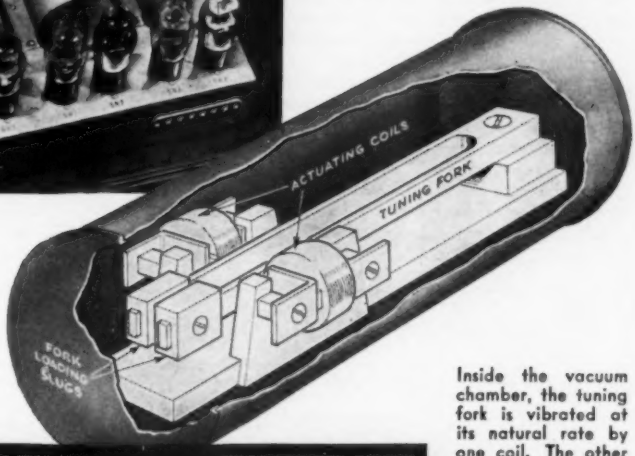
ELECTRIC clocks in 200 studios and control rooms at Radio City, New York, are synchronized by a tuning fork vibrating in a vacuum chamber at 60 cycles a second. Developed and installed by NBC engineers, the system is now in the process of installation at other divisional headquarters. It assures synchronization of clocks within one third of a second a day.

The tuning fork creates infinitesimal pulses, which are amplified millions of times by a series of vacuum tubes until sufficient power is generated to operate the 200 clocks. An A.C. motor, driving a 60-cycle generator that actuates the system, draws current from the regular commercial power lines, but a battery-supplied D.C. motor on the same shaft is switched on automatically if A.C. power fails.

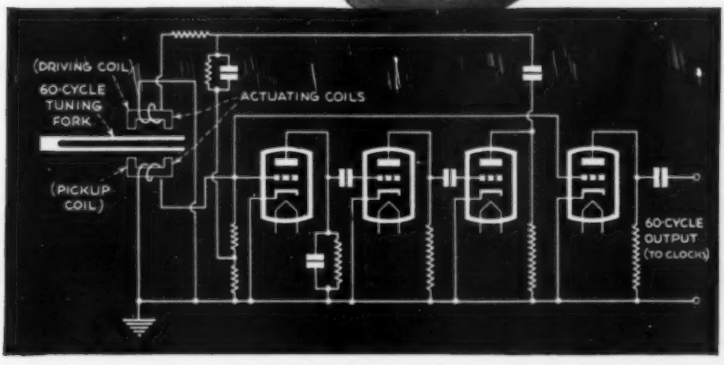
Two secondary tuning forks are included in the system for speeding or retarding the synchronized clocks each time the master clock is checked with the Naval Observatory. One vibrates at 65, the other at 55 cycles.



The cylinders above house tuning forks operating in vacuum—the center one at 60 cycles per second, and the others at 65 and 55 cycles for correction. The tube at the left is a rectifier; the others are oscillators and amplifiers

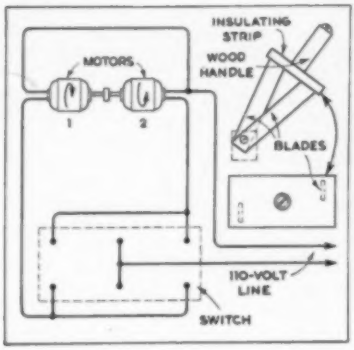


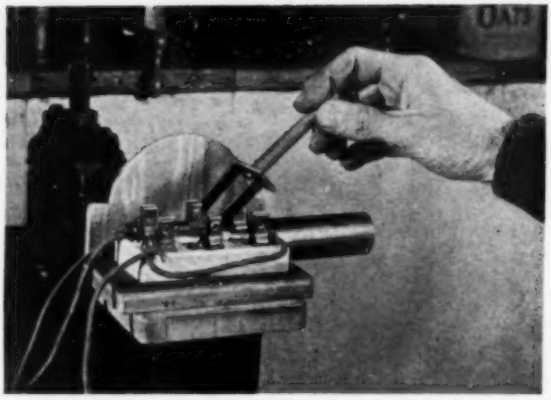
Inside the vacuum chamber, the tuning fork is vibrated at its natural rate by one coil. The other feeds back 60-cycle impulses to the vacuum-tube amplifier



At left is a diagram of the pickup and amplifying circuit of the normally used 60-cycle fork. The output of the fork is amplified until power generated will operate 200 clocks

Double-Pole Switch Used to Control Two Motors





Above is a photograph of a switch controlling two ¼-hp. motors coupled together to power a metal-turning lathe

WHEN large electric motors are not obtainable, two smaller ones can be mounted end to end with their shafts connected by a coupling to form a power unit approximately equal to the combined output of the motors. If these are mounted so that they start up in opposite directions, the direction of rotation of the combined pair is determined by the motor that is started first. After this motor has reached a speed where the starting brushes of both motors are thrown out, the second one is cut into the circuit.

To accomplish this switching operation, you can use a double-pole, double-throw knife switch on which a minor operation has been performed. Remove the insulating strip connecting the two switch blades and replace it with a wider strip that will permit a slight staggering of the blades. Then, when the switch handle is moved toward a closed position, one blade makes contact first, and further movement brings the second blade into contact.

In use with the setup described, the first blade is closed to start the first motor; when the motor has gained sufficient speed to throw out the centrifugal brush mechanism, the second blade also is closed. Be careful not to close both contacts simultaneously. Watch the motors closely, and open the switch instantly if by accident you close both circuits at once and the motors "freeze."—W. E. B.

SPEED OF MOTORS [ELECTRICAL]

THE speed of alternating-current induction motors depends upon the number of poles and the frequency. This can be figured for any motor from the following formula:

$$\frac{\text{Alternations per Minute}}{\text{Number of Poles}} = \text{r.p.m.}$$

As an example, if the frequency is 60 cycles, there are 120 alternations per second. Multiplying this by 60, we get 7,200 alternations per minute. If this is divided by 2, for a two-pole machine, the speed will be 3,600 r.p.m. Divided by 4, for a four-pole machine, the speed is 1,800 r.p.m. If the frequency is 25, by the same calculation, the alternations per minute will be 3,000. Dividing by 2 or 4 as before, the speed will be 1,500 or 750 r.p.m. respectively. This formula does not apply to direct current.

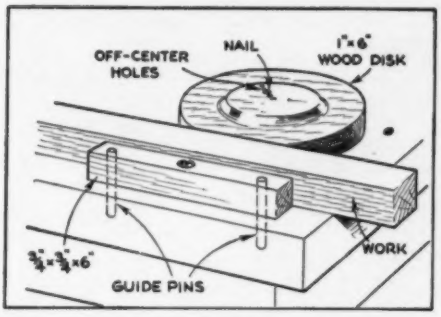
The following table gives the motor speeds obtained by this method for motors on 60-cycle lines:

No. of Poles	Synchronous speed (No Load)	Full Load
2	3600	3470
4	1800	1750
6	1200	1160
8	900	870
10	720	695
12	600	575

POPULAR SCIENCE MONTHLY SHOP DATA

Eccentric Disk Holds Work of Any Size Securely on Bench

THIS eccentric vise holds work on a bench securely, yet opens at a touch. The diameter of the disk can be made to suit your work. Drill several holes through it on a radius, and several holes in the bench to allow for holding stock of various widths. The bench has a removable piece against which the work wedges when the disk is swung around toward it. A heavy nail through a hole in the disk and one in the bench serves as a pivot. The width of the work will determine which of the holes are best to use.

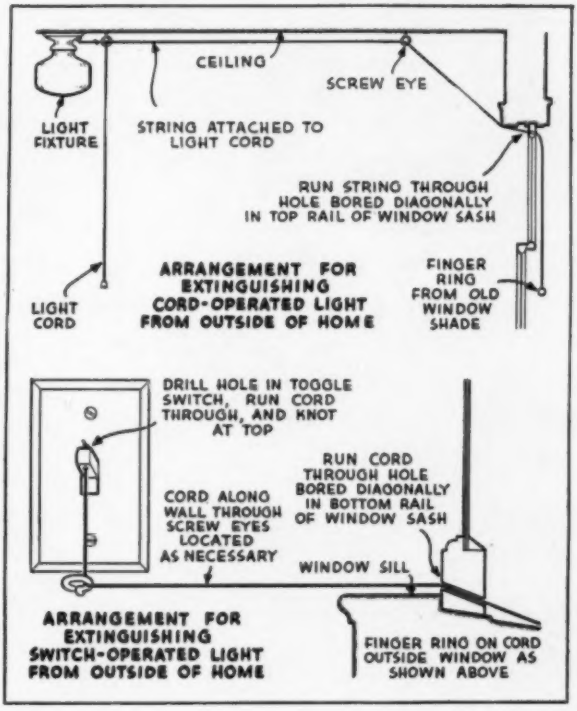


Safeguarding Your Checks

YOU can prevent alterations being made to a check by the use of an ordinary coarse mill file. Place the check face down with the portion on which the written amount appears flat on the surface of the file. Rub the back of the check carefully with a coin or piece of metal. The impression of the file will partly break through the paper and make it impossible to erase or alter the amount on the check.—W. S.

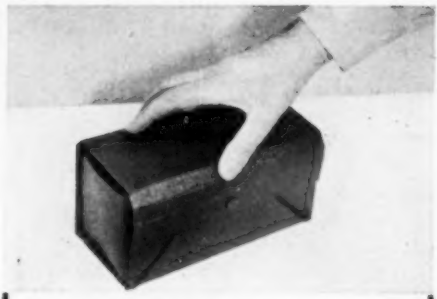
Outside Light Switch for Blackout Use

IF YOU desire to leave a light burning in your house, you can make it easy for your air-raid warden to turn it off from outside should occasion to do so arise while you are absent. On a light fixture which operates by a pull cord, attach a strong cord or fishline to the chain pull and run it along the ceiling, through a small pulley if necessary, to an outside window. In a strip of wood between the top of the upper sash and the window frame, drill a small hole slanting downward. Put the cord through this hole so it will hang outside the window within reach from the ground. On toggle switches, drill a hole through the operating arm, or notch it, and fasten a cord so a pull will flip the switch off. To avoid becoming the butt of practical jokers, keep the extension out of reach except when it is needed.—P. A. B.


CEILING
SCREW EYE
LIGHT FIXTURE
STRING ATTACHED TO LIGHT CORD
RUN STRING THROUGH HOLE BORED DIAGONALLY IN TOP RAIL OF WINDOW SASH
ARRANGEMENT FOR EXTINGUISHING CORD-OPERATED LIGHT FROM OUTSIDE OF HOME
FINGER RING FROM OLD WINDOW SHADE
LIGHT CORD
DRILL HOLE IN TOGGLE SWITCH, RUN CORD THROUGH, AND KNOT AT TOP
RUN CORD THROUGH HOLE BORED DIAGONALLY IN BOTTOM RAIL OF WINDOW SASH
CORD ALONG WALL THROUGH SCREW EYES LOCATED AS NECESSARY
WINDOW SILL
ARRANGEMENT FOR EXTINGUISHING SWITCH-OPERATED LIGHT FROM OUTSIDE OF HOME
FINGER RING ON CORD OUTSIDE WINDOW AS SHOWN ABOVE

AIDS TO WARTIME Housekeeping

A RUBBER-CEMENT SUBSTITUTE now on the market is applied in exactly the same manner as regular rubber cement, and has the same adhesive qualities. The new cement contains neither crude nor reclaimed rubber, and is available in both pint and quart bottles



FOLDING LUNCH BOX. This container made of fiber board and available in blue or brown simulated leather is shown filled in photo above. Below, empty, it can be fitted easily into a man's jacket or coat pocket

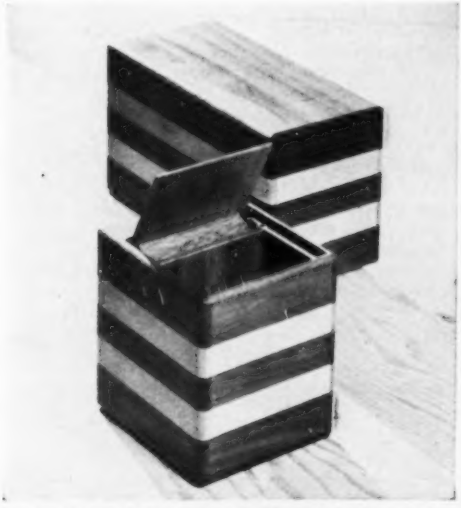
THIS NOVEL CALENDAR BANK lets you know when you're behind in your savings. A nickel, dime, or quarter will change the date, and a quarter inserted in the single slot on the right changes the month

RAZOR BATH SETS save time and tempers. The special fluid, diluted with water and placed in the jar, will keep an undried razor free from rust for weeks. Cutaway view below shows razor in place

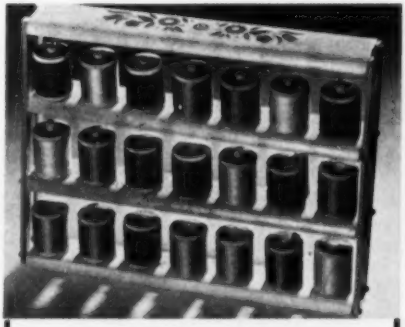
SOAP CAPSULES, each one sufficient to clean the grimiest hands, are convenient for motorists, train travelers, fliers, and the like. The celluloid capsules are about ⅞" long and about ¼" in diameter

PAPER-PLATE DISPENSERS are handy in the kitchen. The front perforations provide an opening for the removal of one plate at a time, and the flap fits back into place to keep dust out. An eyelet in the rear enables the package to be hung on the wall

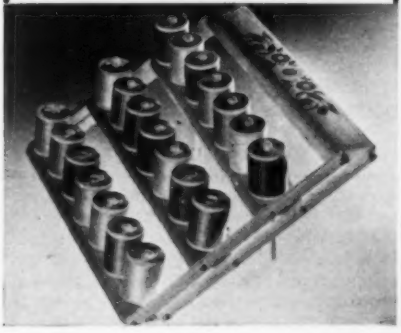
ANY QUART FRUIT JAR can be converted into a thermos bottle by fitting it into the container shown above. Made of heavy paper board with fiber insulation, such a jacket will keep foods hot or cold for several hours

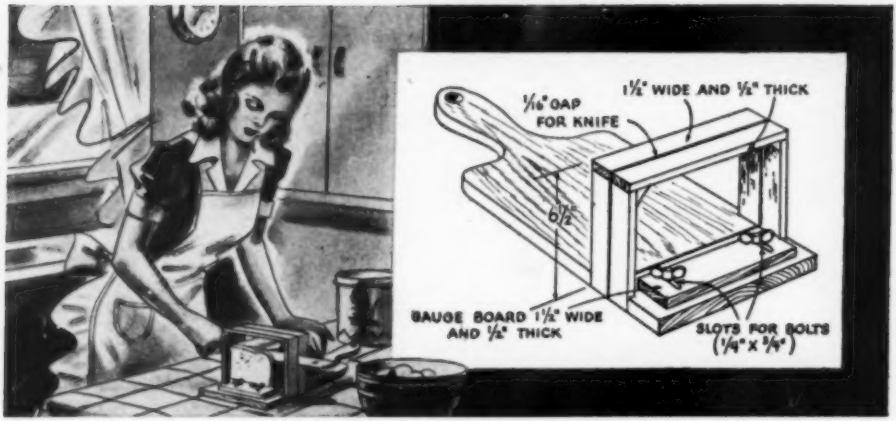


THIS HANDMADE CIGARETTE BOX is as tricky as it is good looking. Simply turn the box on end and the lid automatically pops open, as shown in the photo above. Handsomely and sturdily made of walnut with maple inlays, it will fit into the most modern home, and makes an ideal gift for smokers



FOLDING SPOOL RACK that's handy in the sewing room. When it is closed, as above, the spools cannot fall out or become tangled. Opened out, the rack forms a convenient spool stand, as below





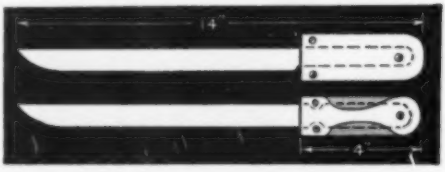
Bread-Knife Gauge Assures Thin and Even Slicing

HOUSEWIVES and those men who like to do a turn in the kitchen are now hacking away unfamiliarly with the bread knife after years of buying bread presliced at the bakery. For those who have lost the expert touch, here is a bread "miter box" to put an end to thick, jagged hunks and help toward the Government's goal of less waste. It not only assures even cutting, but also has an adjustable stop for making uniform slices of any thickness desired.

The base is an ordinary bread board, such as can be obtained at any store handling kitchenware. The knife guides are made from maple, built in two sections, as shown, and spaced 1/16" apart to allow free movement of the knife without wobble. Dado the edges of the baseboard and attach the frame with glue and countersunk screws. Blocks reinforce the upper corners. A ⅛" deep groove may be sawed across the board to receive the knife at the end of its stroke, so as to minimize dulling of the edge.

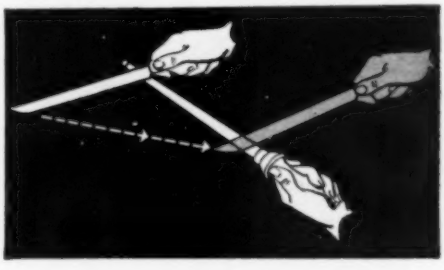
Drive square-shouldered carriage bolts for the thickness gauge into counterbored holes from beneath. They should be tight enough not to turn when the wing nuts are being tightened. A slice-thickness scale may be marked on the board.

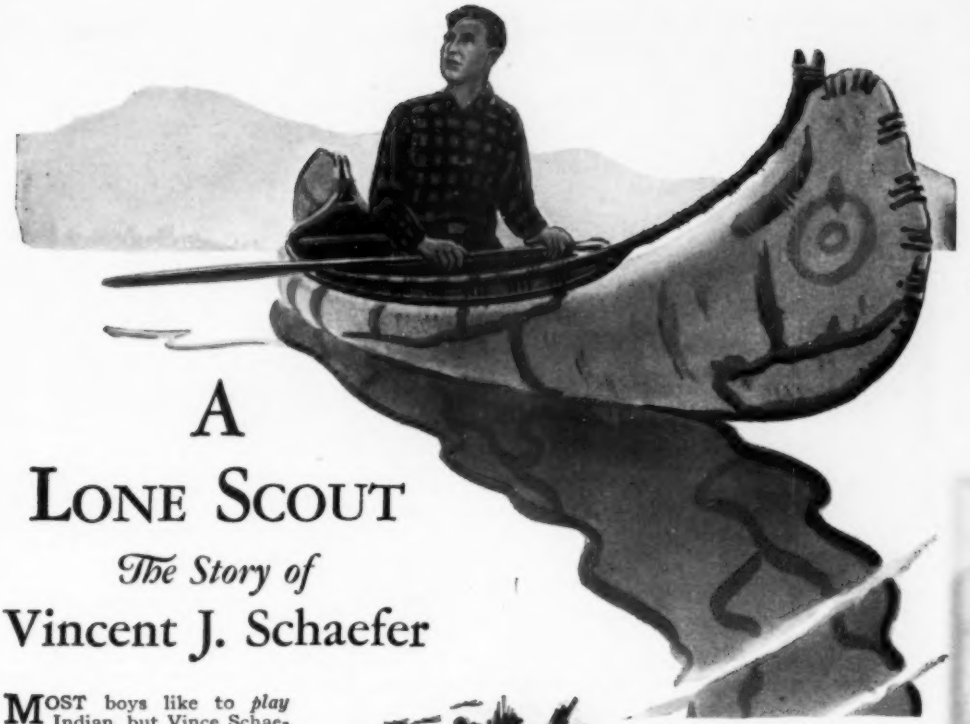
In slicing bread, use a long, sharp knife with either a plain or scalloped edge, and cut with a sawing motion. Very fresh bread is likely to be soft and will give even with minimum pressure. This can be offset by turning the loaf on its side and slicing against the harder crust of the bottom.



KNIVES THAT WILL STAY SHARP are often costly, but one can be made from a discarded power hack-saw blade that will cut through gristle and bone and still keep an edge keen enough for slicing hot bread. An old blade may be obtained from a machine shop, foundry, or large garage, but get one that is all hard, not one with a soft back. Grind off and taper one end, as shown; then grind the cutting edge slowly so that it does not burn. Grind the butt narrower or notch it for the handle rivets as shown, and sandwich the blade between two shaped pieces of wood, filling the crack with composition wood.

SHARPENING A KNIFE on an ordinary kitchen stone or steel requires a simple technique that is easy to learn. Keeping the cutting edge foremost and the blade tilted slightly, so that it will retain its bevel, start the stroke at the "heel" and sweep downward diagonally to cover the entire length from heel to point in one stroke. Alternate strokes from one side of the blade to the other, and do not use much pressure.



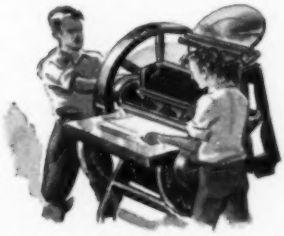


A LONE SCOUT

The Story of Vincent J. Schaefer

MOST boys like to *play* Indian, but Vince Schaefer liked to *study* Indians.

He studied Indians by studying arrowheads. He could learn a lot about a tribe's culture from its arrowhead.



A Lone Scout, Vince started writing to Lone Scouts all over the world who were interested in archaeology.

That started Vince thinking. Before long he and some of his classmates were publishing a magazine on archaeology.

Scouting introduced Vince to many interesting fields of study. And these studies stood him in good stead in later years for, when he was a sophomore, Vince had to leave high school and go to work.

First he worked as an apprentice machinist at the G.E. He graduated to become a toolmaker and later a model maker in the lab. In between times he was a tree surgeon and an assistant archaeologist.

When he wasn't on the job, he was studying—*teaching himself*. And he must have been a good teacher, for in 1933 Dr. Langmuir, famous Nobel Prize winner, asked Vince to be his assistant in the G-E Research Laboratory.

Vince has never stopped studying. Old barns, photography, fossils, caves. . . .

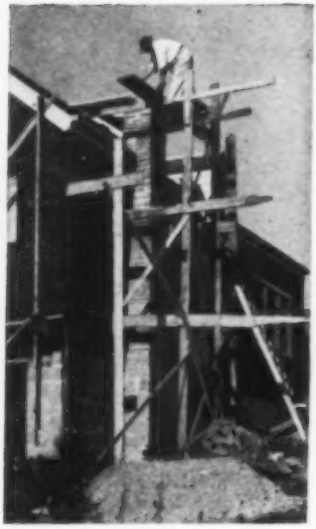
As a hobby, he developed a method of preserving snowflakes. This process is now used with the electron microscope to learn more about the metals going into tanks and planes.

Right now Vince is studying harder than ever; he is working on war problems. But he still finds time for scouting!

"We only point the way for others to carry on," is the way the young scientist looks at research. And America is counting on the keen, ambitious boys of today to carry on and to point the way to an even greater future. *General Electric, Schenectady, N. Y.*

GENERAL ELECTRIC

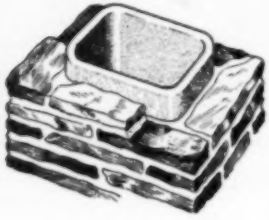
966-15E-211



Colorful Facing for a Chimney Made with Broken Pieces of Flagstones

WASTE pieces of colored flagstone left over from a job of paving a walk, terrace, or porch can be put to good use as a chimney facing if substituted for common brick or field stone. Fitted and cemented around the tile flue lining in the manner shown, the thin layers of flagstone form an unusual multicolored pattern.

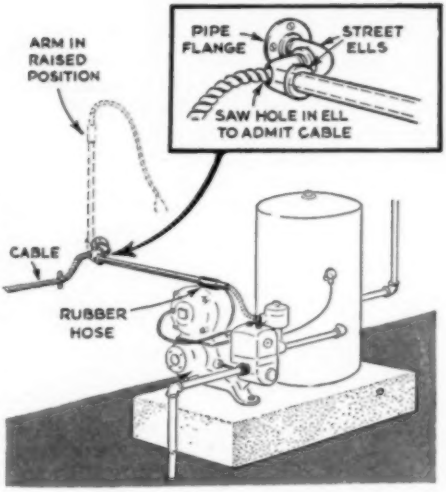
Trim and lay flagstones so that regular bonds occur at corners



If you need a considerable quantity for facing a large house chimney, see your local building-supply dealer about buying up his stock of broken pieces. It takes only a few scraps, however, to add a distinctive touch to a small cottage chimney or an outdoor picnic fireplace.

Movable Pipe Arm Protects Electric Cable to Pump

WHERE a house water pump rests on a base set away from the cellar wall, the flexible cable supplying current to the pump can be protected from injury by running the cable through a supporting arm assembled from pipe fittings and screwed to the wall as shown. Two street ells form the swivel joint which permits the arm to be turned up out of the way against the wall whenever the cable must be disconnected for the purpose of servicing the pump. When in use, the free end of the arm rests on the motor. A short length of rubber hose, slipped over the end of the arm, serves as a cushion to eliminate noise due to vibration.—J. MODROCH.

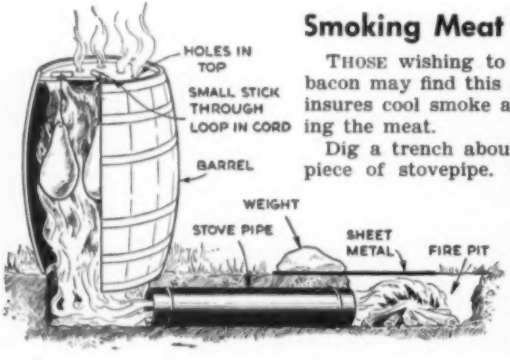


Smoking Meat with Barrel and Stove Pipe

THOSE wishing to smoke only a few hams or sides of bacon may find this simple method of interest. The tunnel insures cool smoke and eliminates the danger of overheating the meat.

Dig a trench about 12" deep and twice the length of a piece of stovepipe. Bury the pipe in the middle of the trench. Over one of the open ends place a barrel upside down and bore a few holes in the top of it. Hang the meat with cords looped over small sticks.

In the other end of the trench build a fire with chips and corn cobs or hickory wood. Regulate the draft with a piece of sheet metal.—H. L. S.



$1,000 FOR YOUR IDEAS In the Big Marlin Gun Contest!

Now here's a chance for you hunters and target shooting fans, to *cash in* on your knowledge of guns! Marlin—always on the lookout for new ideas to improve sporting firearms—wants to hear from you. Sportsmen and gun dealers are cordially invited to join Marlin's big Gun Contest—with $1,000 in cash prizes to shoot at. And remember, many a good idea is simple and easy to describe. Your chance is as good as the next fellow's to win a prize. It's easy to get in the contest—read the details below and send your entry in today! Contest ends July 1, 1943.

Jot down your idea for improving any current model Marlin Gun. Follow the simple contest rules and send your entry in. If you wish, you may suggest new features, not at present in the line. A free catalog is yours for the asking, to review the features of Marlin Guns.

PRIZES IN THE BIG MARLIN CONTEST

The first prize is $500.00 in cash; second prize $100; third prize $50.00; fourteen additional prizes of $25.00 cash each. Seventeen prizes in all! (Marlin suggests the purchase of U.S. Savings Bonds with the prize money.)

JUDGING

Three famous gun editors—Bob Nichols of Field & Stream, Jack O'Connor of Outdoor Life, Maj. Chas. Askins of Sports Afield—will select the winning entries. All ideas for which prizes are given become the property of The Marlin Firearms Company and none will be returned. Prizes awarded for the seventeen ideas which are most valuable and practical, in the opinion of the judges. Duplicate prizes awarded in the event of a tie. WINNERS will be determined and prizes announced as soon as possible.

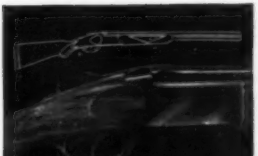
CONTEST RULES

The Marlin Gun Contest is open to all sportsmen and dealers in guns, with the exception of Marlin employees. Written suggestions must not exceed 300 words, the shorter the better. No limit to number of entries which may be submitted. Write name and address clearly on each suggestion. Mail entries to Dept. K, The Marlin Firearms Co., 17 E. 42nd St., New York City.

Entries must be received on or before July 1, 1943.

Win cash with your ideas! Enter the Marlin Contest today.

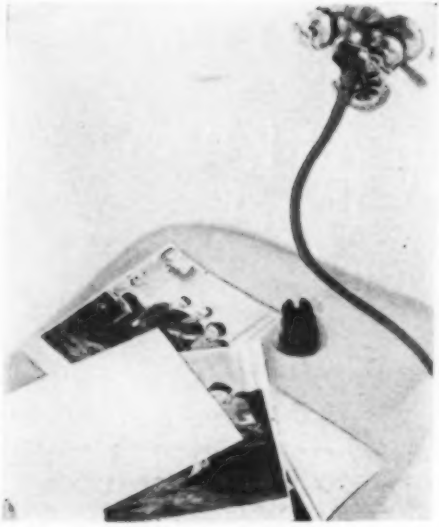
The Marlin Firearms plant is now 100% on war production.



Marlin's Over & Under Shotgun, in 12, 16 and 20 gauges and .410 bore, is hammerless, cocks on opening, has sturdy one-piece frame.

All Marlin rifles—lever action, clip and tubular magazine and .22 automatic, feature deep-cut, accurate, "Ballard" rifling.

Marlin lever action rifles, in calibers .22, .30-.30 and .32 Spec., have the solid-top, case-hardened receiver, with safe side ejection.



Print-Washing Drain Made from Auto Radiator Hose

FOR washing a number of large prints, a bathtub, wash tray, sink, or lavatory can be used if the drain is fitted with the device illustrated. This carries away the hypo-laden water from the bottom and allows the surplus to flow over the top.

The washer consists of a 4" length of automobile radiator hose of a diameter to fit into the drain snugly. A ⅜" hole is cut in it about ½" from the bottom, and three or four ¾" deep notches are cut at the top. Push into the drain until the small hole is just above the bottom of the tub or sink.—W. L. BURKHARD.

Wetting Agent Causes Colors to Flow on Glossy Prints

ANYBODY who has tried to tint glossy prints with water colors knows how hard it is to make the color go on smoothly. It usually gathers into drops that defy the brush. To overcome this difficulty, I add 3 drops of wetting agent to 1 oz. of the water used. This decreases the surface tension so that the color spreads into a thin film wherever the brush guides it. It is not necessary to "work" it in. Any standard wetting agent, obtainable from photographic supply houses, will do.—SHIRLEY GADDIS.

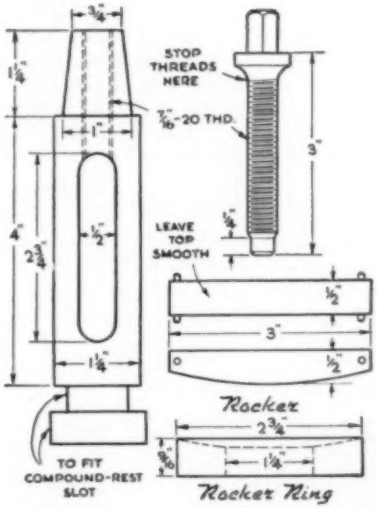
Rocker of Shopmade Tool Post Cannot Fall Out of Slot

NEED an extra tool post? Here's a husky one you can make entirely of mild steel on the lathe itself. I have used this type for almost 40 years and still find it superior to commercial ones. The rocker cannot fall out or be mislaid, and the screw has a large flange and a fillet that prevent its bending if the wrench is accidentally hit.

After turning the body, drill a 25/64" screw hole right down to the bottom of the tool slot, which aids in finishing the slot. Clamp the body horizontally to the compound rest and drill a ½" hole through at either end of the slot. Then chuck a solid hand reamer in the lathe and use this as a milling cutter to finish the slot.

Turn the screw also from mild steel, stopping the thread about ¼" below the fillet. Make the nut about one and a half times as high as the thickness of the wrench. The faces can be machined with a fly cutter held in the lathe chuck.

Leave the top of the rocker smooth. This will give it a firmer grip than if it is checkered and hardened. Drill a ⅛" hole at each end as shown and drive in tightly fitting pins, the second one after the rocker has been inserted in the tool slot. Caseharden only the screw.—HARRY L. ALLEN.



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A list of the products covered by this new, wartime service; and a brief statement of what they require, and why; are given at the right of this page. For your own good, and for the conservation of America's gas, oil and tires, follow the suggestions given.

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SPARK PLUGS—Dirty or worn plugs waste up to 10% on gas. They also cause hard starting, weaken your battery. Have your plugs cleaned and adjusted every few months.

AIR CLEANERS—A dirty air cleaner restricts the flow of air into the carburetor, reduces gasoline economy. Have your air cleaner rinsed every time your car is lubricated.

FUEL PUMPS—Practically trouble free. However, if yours has been in use thirty or forty thousand miles, a check-up is probably due.

OIL FILTERS—Slow driving accelerates formation of soot and carbon in engine oil. This dirt will clog piston rings, cause increased consumption of oil and gas. Replace your oil filter element when AC Test Pad shows oil is dirty.

SPEEDOMETERS—Speedometers are very reliable, seldom give trouble. Keep them in good condition.

AMMETERS—Very reliable, seldom require service. Must be kept in good condition because they show whether the battery is being charged or drained.

OIL PRESSURE GAUGES—If they stop functioning, SWITCH OFF THE ENGINE, call a competent service man at once. Usually, the trouble is in the oil supply system.

GASOLINE GAUGES need to be kept in reliable condition, although they seldom need service.

TEMPERATURE GAUGES—your only indicators of engine heat. Although very reliable, they should be kept in condition.

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World's Best Flyers

(Continued from page 102)

bolted to the fuselage. The ship cruises at about 150 m.p.h. and has a range of 600 miles. In the same general class are the Vultee, the BT-13 and 15, similar designs powered respectively with 450-hp. Pratt & Whitney Wasp and 420 Wright Whirlwind engines.

In the advanced trainer, flying takes on a serious military aspect. This ship has most of the characteristics of a full-grown military airplane—guns, retractable landing gear, high-compression engines, full navigational instruments, complete radio. Here the cadet begins simulated combat training during the day and cross-country at night. He flies tight formation, lands in small, unfamiliar fields, shoots the trainer's fixed guns, gets the theory of combat, and is further indoctrinated in the science of air warfare. The North American AT-6 has been currently standardized for this job, and turned out in large volume production. This ship is reputed to be the toughest airplane ever built, structurally and operationally. Its wing is all aluminum alloy, with two spars in its center section and one in the outboard panels. Still being a trainer, it bears the last semblance of the steel-tube structure in a part of the fuselage up to the back cockpit. No great effort has been made to make this ship easy to fly. While it is no man-killer, it contains all the potential headaches of fighting ships but in a lesser degree. The AT-6 has a 600-hp. engine and all the grief that comes with it. The cadet learns to baby his engine after take-off, the art of getting the maximum performance out of his power plant on long cross-country flights. He has learned advance aerobatics, elementary gunnery. In the primary and basic types, the cadet has learned to be a pilot; in the AT series he learns to be a sky soldier.

By the time the student completes Advanced Training, his instructors know what kind of pilot he is going to be. The pursuit-talented kids go off to their particular type of advanced and operational training, the bombers go to be molded into an integrated crew.

Basic combat trainers are merely AT's armed with four .30 caliber fixed machine guns and a couple of camera guns. The pursuit pilot's life from this point on is filled with aerobatics and gunnery. He graduates to obsolescent P-40's and is finally polished off in the latest equipment, taught operations, and sent to a combat unit

(Continued on page 212)

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World's Best Flyers

(Continued from page 210)

which finally teaches him local conditions whose acquaintance is the price of survival.

The bombardment-pilot cadet has, in the meantime, joined up with units handling twin-engined trainers which first give him the rudiments of multi-engined ships. The Curtiss AT-9 and the Cessna AT-17 teach him the fine art of engine synchronization, how to fly with one engine dead, and the complicated procedures of handling engines, props, flaps, and the 13 other major considerations in taking off and landing larger ships. Furthermore, he learns the art of dividing the job with a copilot. In the meantime, other members of the air crew have been selected and trained. The officer members he left behind in the classification centers as bombardier and navigator join up at this point.

The secrecy that shrouds the bombsight prevents discussion of the bombardier's training, but it should suffice to say that these lads can hit a pickle barrel from 10,000 feet. They have gotten most of their practice in the Beechcraft AT-11s, a twin-engined job powered by 450-hp. Pratt & Whitney Wasps. The navigator's time has been spent chiefly in the AT-7, similar to the 11, lacking only the bombardier's nose.

The next step is into crew trainers. Here the other members of the bomber's crew—radio operator, flight engineer, and armorer—are added. These men are non-commissioned officers, graduated from the special schools of the Air Forces Technical Training Command. Specialists in their individual fields, they were found physically and temperamentally fit to be air-crew members, and, after completing their specialized ground training, were sent to gunnery schools to learn the art of handling the free and turret-mounted .50 caliber machine guns that arm our bombers. The bombardier and navigator also got flexible gunnery practice, so that they can man their posts when the bomber goes into combat.

From the crew trainers, the men enter the ships in which they will finally face the enemy. Veterans, back from combat units (we have some after a year of war), give the new crews the latest dope on combat and survival. Then they are shipped off to the theaters of war. They are not, however, flung into battle immediately. The process of indoctrination continues. Operational training under escort, in formation with veterans of the area, gives the new men the feel of being artists in destruction.

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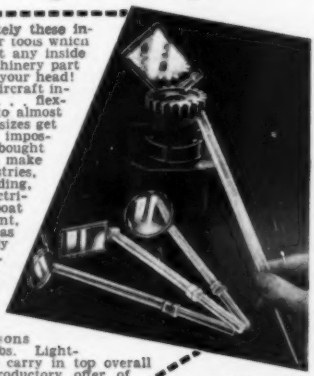

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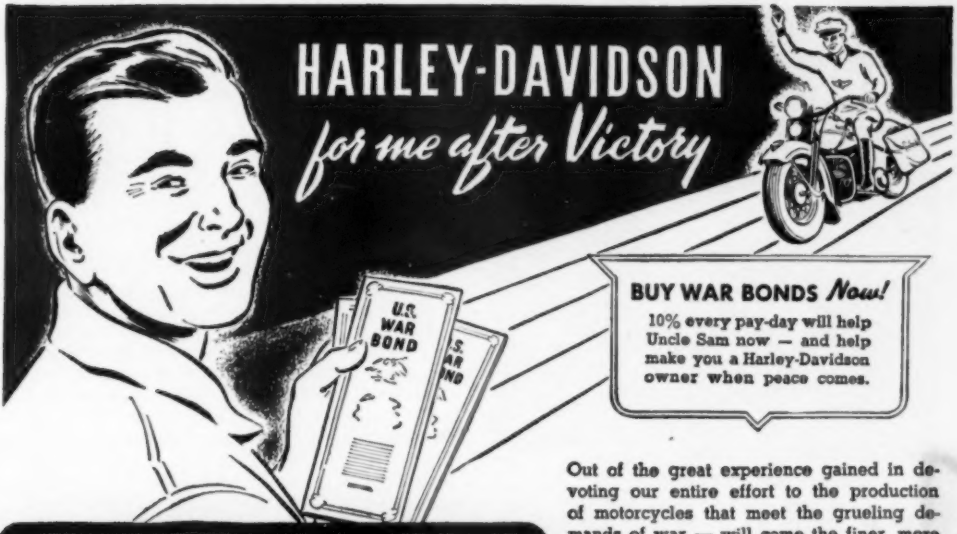
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Battle of the Kilowatts

(Continued from page 113)

total of 90 billion kilowatt hours a year.

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In addition to Boulder and Grand Coulee, between 1908 and 1941 the Bureau of Reclamation built 26 smaller hydroelectric plants on 15 projects in 11 Western and Southwestern states. Their aggregate generating capacity is close to a quarter million kilowatts. Several large dams are under construction—the biggest is 602-foot-high, 375,000-kilowatt Shasta Dam on the Sacramento River, keystone of the Central Valley Project in northern California. It is over three-quarters completed, but generators ordered for it have been installed at Grand Coulee.

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The oldest of these plants and the one with the largest generating capacity—288,000 kilowatts—is Wilson Dam, started in 1918 to supply power to the World War nitrate plants of the Muscle Shoals area. Pickwick, Norris, Wheeler, and Chicka-

(Continued on page 218)

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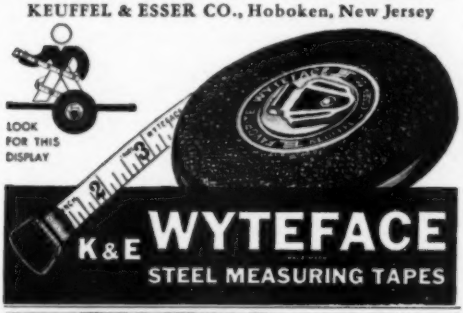

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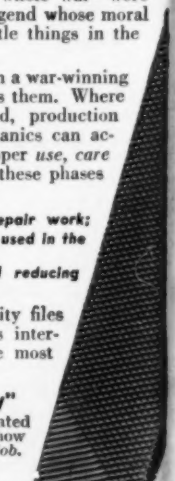

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Battle of the Kilowatts

(Continued from page 216)

mauga dams all have generating capacities of over 100,000 kilowatts. Several new dams are under construction—among them the 450-foot Fontana Dam on the Little Tennessee River in North Carolina, which will be the highest dam east of the Rocky Mountains and will have a generating capacity of 200,000 kilowatts; Kentucky Dam on the Tennessee River near Paducah, Ky., which will be the biggest dam east of the Mississippi and will have a generating capacity of 128,000 kilowatts; Appalachia Dam on the Hiwassee River; and Douglas Dam on the French Broad River.

A number of large-scale hydroelectric developments have been undertaken by state power authorities. The 130,000-kilowatt Santee-Cooper project is nearing completion in South Carolina. Work has been started on important developments on the Lower Colorado and Brazos rivers in Texas.

While the greatest developments, requiring enormous capital investments, have been financed with the public's money, there are many important privately owned hydroelectric plants. The largest is the 178,450-kilowatt Schoelkopf Station of the Niagara Hudson Power Corporation. The Comerford plant of the Connecticut River Power Company has a generating capacity of 156,000 kilowatts, and is the largest in New England. Conowingo Dam, in northern Maryland, produces 1 1/3 billion kilowatt hours of power a year. Operated in conjunction with two other plants farther up the Susquehanna River, it supplies power to the vital Baltimore, Philadelphia, and southern New Jersey industrial areas.

The end of the war almost certainly will be the beginning of an era of tremendous Government-financed hydroelectric development. The Bureau of Reclamation will complete projects on which it has suspended work, and start several new ones. Several states will go ahead with important power-production projects now authorized. Hydroelectric developments may be made more attractive to private capital by advances in the field of high-voltage power transmission which will make possible the low-cost transmission of water-power-generated electricity to localities many hundreds of miles from where it is produced. A way may even be found to stockpile electricity for use when it is needed—an advance which would reduce production costs by obviating the need for expensive stand-by generating equipment which is used only when current requirements are abnormally high.

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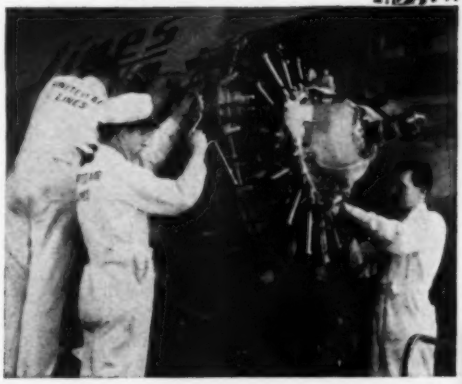

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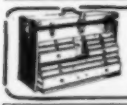

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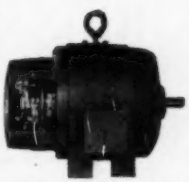

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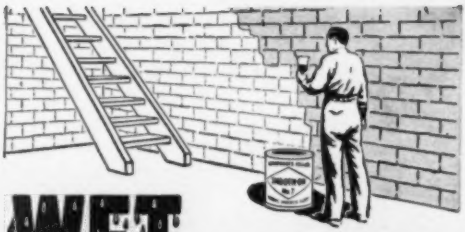

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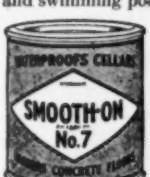

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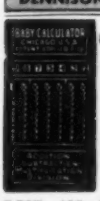

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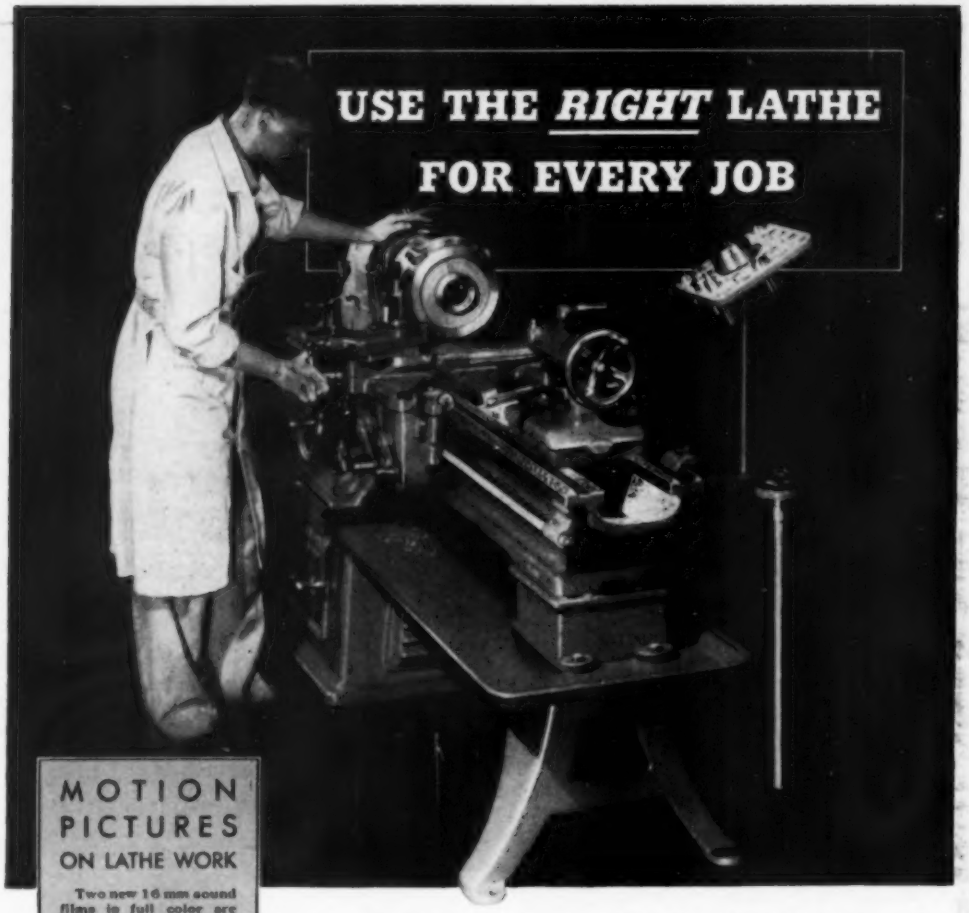

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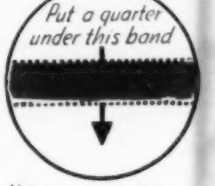

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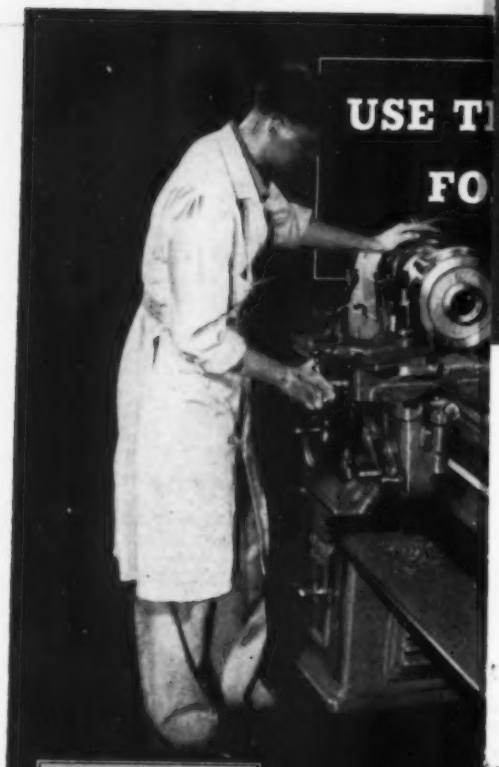

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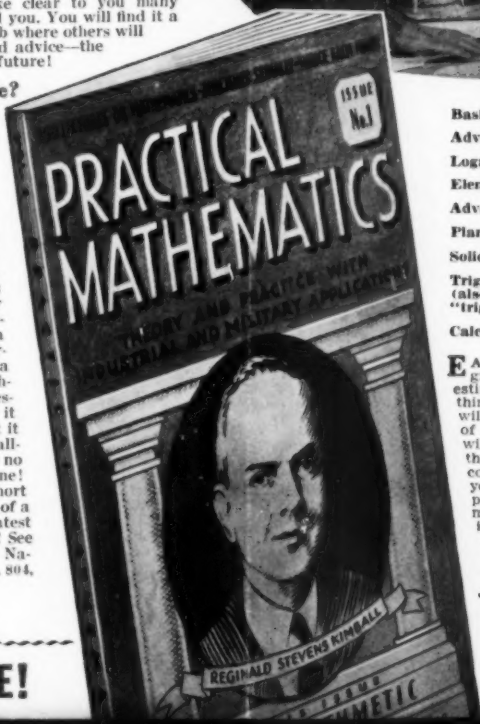

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